POWER PLANT ENGINEERING

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Power from Exhaust Steam

EXHAUST STEAM DRIVES TURBO-GENERATORS AT WESTERN DROP FORGE CO. PLANT

THE MODERN STEAM hammer under the control of a skilled operator is a wonderfully sensitive device considering its massive design and it is said that an experienced operator can manipulate the control levers with such skill that the hammer may be brought down upon the face of a watch without breaking the crystal. Without questioning the veracity of the foregoing statement, we admit that it would be interesting to see this feat performed—on somebody else's watch.

The steam hammer, however, in spite of its sensitiveness and its application to modern industry is a wasteful device, that is, as regards thermal efficiency. The thermal efficiency of the best steam turbines or engines is only about 20 per cent running condensing, and 10 or 13 per cent running non-condensing. The steam hammer, being a much more extravagant user of steam than the highly developed steam engine of today, will have a correspondingly lower efficiency.

It is obvious, therefore, that in a plant equipped with a number of steam hammers, unless some provision is made for using the exhaust steam from the hammers, a great deal of heat will be wasted. At least 85 per cent of the heat will be lost in the exhaust. Owners of plants equipped with such apparatus soon come to realize this fact and as a consequence a number of these plants use the exhaust for electric generating purposes.

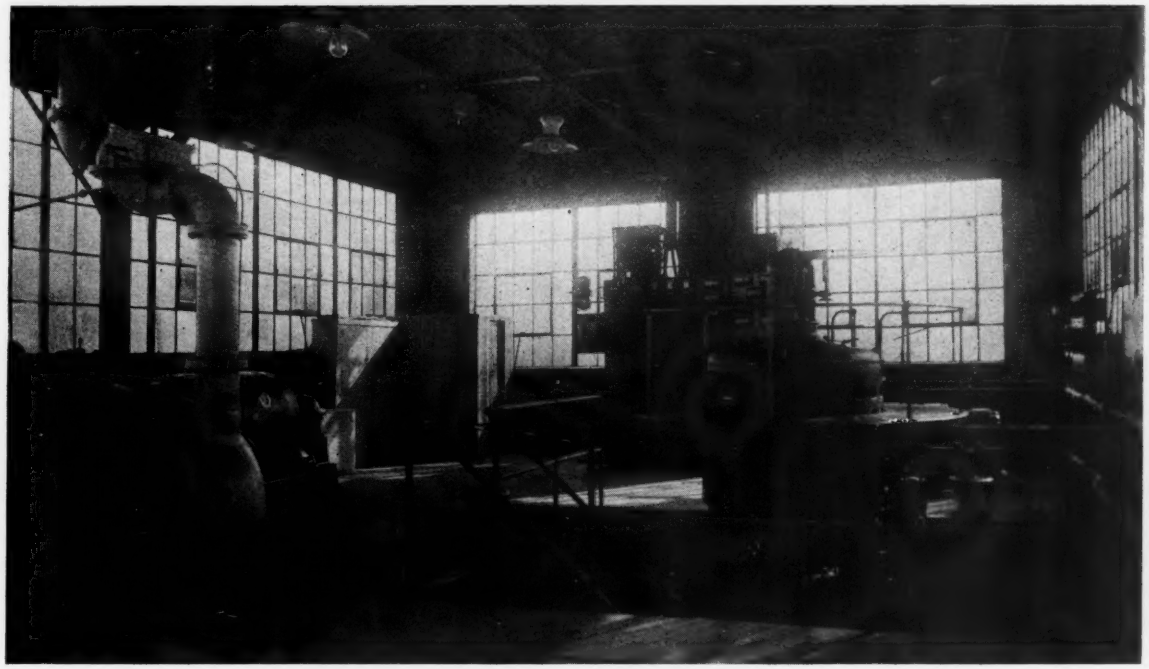


FIG. 1. PARTIAL VIEW OF THE TURBINE ROOM

The Western Drop Forge Co. at Marion, Ind., claim to be the first drop forge plant to utilize the exhaust from the hammers in this manner, and their power plant which has recently been enlarged, is arranged to supply not only the demands of the factory, but the local public service company as well when an excess amount of steam is available. Conversely, when the load in the factory

exceeds the capacity of the power plant, electric current is supplied by the public service company. In this manner, the highest efficiency of the generating equipment is secured at all times, and uninterrupted service assured.

Electric energy, therefore, is the most inexpensive form of power available and, as usual in plants of this type, electric motors are employed wherever possible. Large forging machines and a number of steam hammers ranging in size from small ones of 400 lb. to large ones of 7500 lb. assure an abundance of exhaust steam for power and heating purposes at all times of normal load.

The Boiler Room

Contrary to usual power plant practice, the boiler room at this plant is located at some distance from the engine room. This, however, is no disadvantage since all boilers recently installed are of the most modern design and especial precautions were taken in the construction of the settings. The inside walls and combustion chambers were lined with extra thicknesses of fire brick and the back walls lined with fire brick the full height of the setting. These boilers are equipped with chain grate stokers and can be operated normally at 175 per cent of rated capacity.

All boilers operate on forced draft, each being fitted with its individual turbo-blower located underneath the grates in the ash pit. Ample draft above the fuel bed is secured by a concrete stack 185 ft. in height which has recently been built. Damper regulators are provided which control both the operation of the damper and the speed of the blower engines. Draft gages are fitted on each boiler and pyrometers record the temperature of the gases at the last pass.

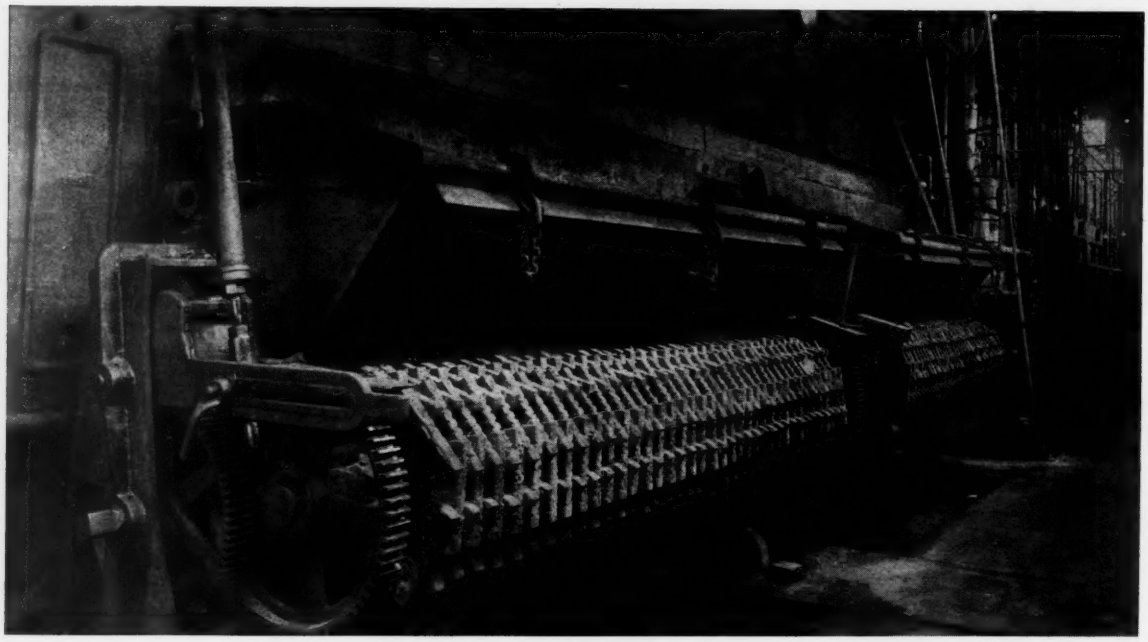


FIG. 2. THE BOILER ROOM

of the steam used by the turbo generators must first be used in the steam hammers, and since these are more or less scattered throughout the factory, it matters little whether the engine room is located adjacent to the boiler room or not. Furthermore, since the turbine room is located directly on a river bank, an ample supply of circulating water is thus insured without the necessity of pumping this water over a comparatively long distance which would be the case if the electric power plant was combined in the same building with the boiler room.

Steam is generated at a pressure of 135 lb. per sq. in. by seven water-tube boilers; two 502-hp., two 300-hp., two 350-hp. and one 250-hp., giving a total rated capacity of over 2500 hp. All steam, before going into the factory for use in the hammers, however, is passed through a regulating valve and the pressure reduced to 100 lb. This insures a constant pressure which is essential to steam hammer operation. With the exception of the two new 502-hp. boilers, all boilers were hand-fired, but chain grate stokers are now being installed. The two new

Under normal operating conditions, the stokers are driven by electric motors but may also be operated by a reciprocating engine connected to the same line shafting. The engine, however, is used only in emergency cases when the electric supply fails or in case of accident to the motors.

Feed water is treated by a hot process softening apparatus, is measured by a 4-in. meter and is delivered to the boilers by two duplex direct acting boiler feed pumps which are controlled by automatic regulators.

Coal and Ash Handling Machinery

Coal is handled by an overhead trolley carrier, which unloads directly from a pit underneath the railroad cars and delivers into the coal bunkers in front of the boiler room as shown in Fig. 3. While this conveyor may also be used for handling ashes in times of emergency by lowering the bucket into the pit shown in Fig. 3, all ashes are normally handled by a steam jet ash conveyor of modern design.

Ashes are introduced into the openings in the conveyor line in front of each ash hopper, and the action of the steam jet carries the ashes up into a cast-iron storage hopper from which it is discharged by gravity into trucks

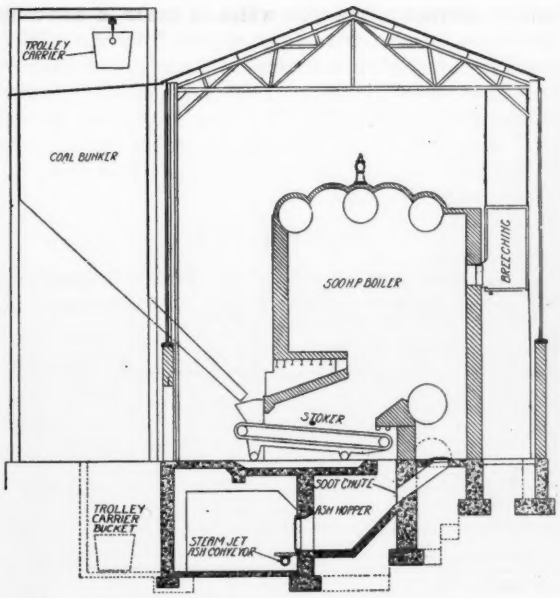


FIG. 3. SECTION THROUGH BOILER ROOM SHOWING COAL BUNKERS AND TROLLEY CARRIER

or cars below. Cast iron has proven most successful in resisting the corrosive action of moist ashes and therefore makes a most desirable hopper material. Although the tank is supported on a structural steel frame, this

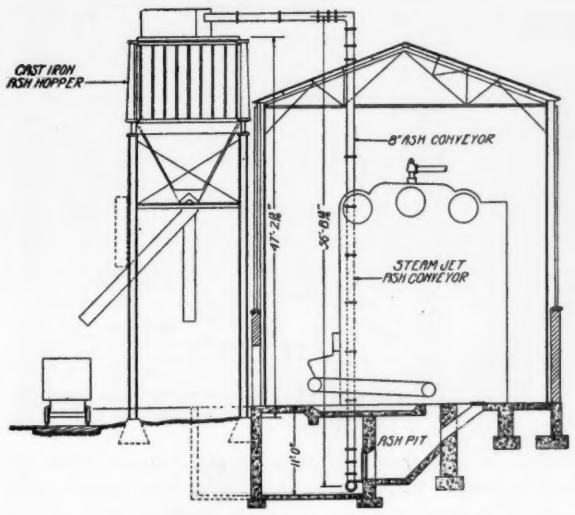


FIG. 4. SECTION THROUGH BOILER ROOM SHOWING STEAM JET ASH CONVEYOR AND ASH HOPPER

frame is entirely independent of the storage chamber and at no time does ash come in contact with the steel supports. The cross section in Fig. 4 shows the general arrangement of this system as installed.

THE TURBINE ROOM

AS PREVIOUSLY stated, the turbine house is located on a river bank some 400 ft. from the boiler room. It consists of a one-story brick building amply lighted by large windows on three sides, and houses all necessary equipment for generating the electric energy used at

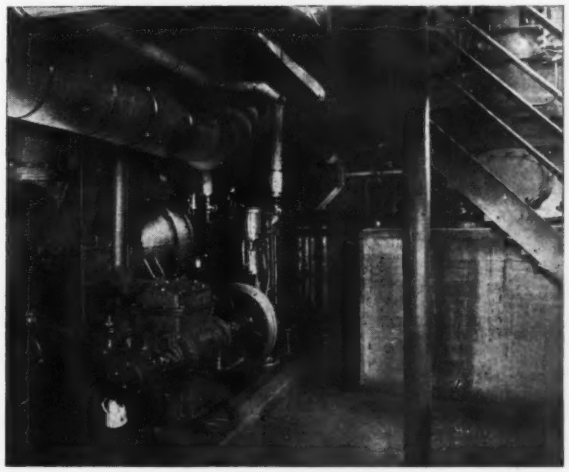


FIG. 5. VIEW IN BASEMENT OF TURBINE ROOM SHOWING ROTARY VACUUM PUMP

the factory. A view of the turbine floor is shown in Fig. 1, while basement views are shown in Figs. 5 and 6.

Two turbo-generators, one a 300-kv.a., 200-v., 3-phase, 60-cycle horizontal machine with direct connected exciter, and the other a 500-kv.a., 2300-v., 3-phase, 60-cycle vertical machine with a separate motor driven exciter,

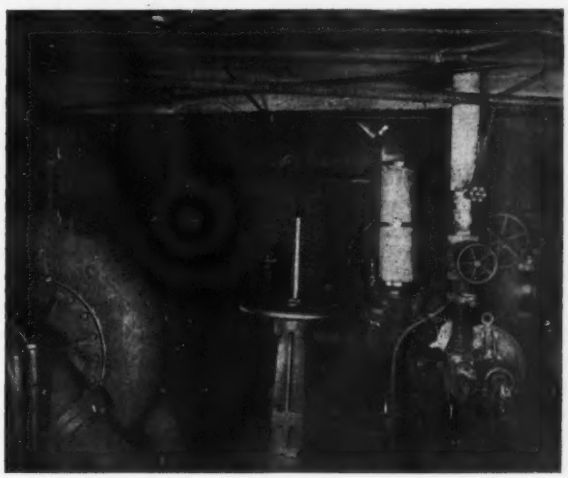


FIG. 6. BASEMENT VIEW SHOWING MOTOR AND TURBINE DRIVEN CIRCULATING PUMPS

together with necessary condensing apparatus form the main units.

Both units are fitted with surface condensers, rotary vacuum pumps and centrifugal circulating pumps. Each condensing unit is fitted with two circulating pumps, one motor driven and one turbine driven, thus insuring uninterrupted service at all times. The circulating units

take water from a sump connected with a large concrete cistern 50 ft. in diameter and about 24 ft. deep. This cistern, which is situated below the normal water level of the river, is fed from the latter by gravity, and serves as a settling tank. After passing through the condenser, as shown in the elevation Fig. 7, the water is discharged back into the river. The two circulating pumps shown diagrammatically in Fig. 7 may also be seen in the photograph, Fig. 6.

One of the rotary vacuum pumps illustrated in Fig. 5 is shown diagrammatically in Fig. 10. The cylindrical rotor, A, is mounted eccentrically on a shaft supported in outboard bearings. An oscillating cam, B, operated from the rotor shaft by means of external cranks and connecting rod, separates the suction and discharge sides of the pump cylinder, and follows the motion of the rotor with small clearance. Air is drawn in through the

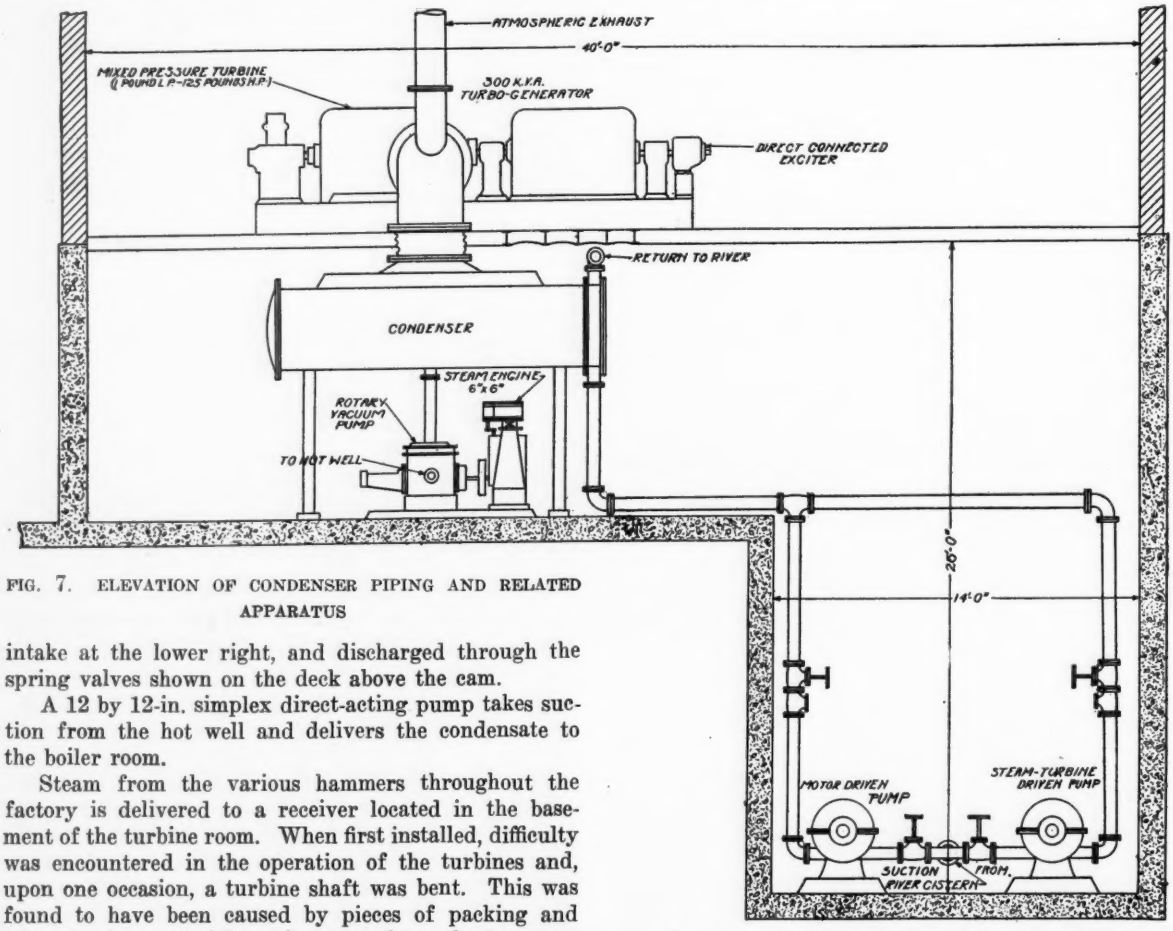


FIG. 7. ELEVATION OF CONDENSER PIPING AND RELATED APPARATUS

intake at the lower right, and discharged through the spring valves shown on the deck above the cam.

A 12 by 12-in. simplex direct-acting pump takes suction from the hot well and delivers the condensate to the boiler room.

Steam from the various hammers throughout the factory is delivered to a receiver located in the basement of the turbine room. When first installed, difficulty was encountered in the operation of the turbines and, upon one occasion, a turbine shaft was bent. This was found to have been caused by pieces of packing and other foreign material coming over from the hammers and entering the turbine. A baffle arrangement and a hand-hole plate was therefore fitted to the receiver which effectually impedes all foreign material and enables it to be removed through the hand-hole.

From the receiver, the steam passes through an oil separator and is finally delivered to the turbines at a pressure of about 3 lb. per sq. in.

Electrical Features

Current is generated at two voltages, 2300 and 220. The vertical machine generating at 2300 v. can be synchronized and directly connected with the 2300-v. city mains of the public service company. The horizontal machine generates at 220 v. and may be connected to the city mains through a bank of transformers. In times of light load therefore, either or both generators may supply current to the city, while in times of abnormally heavy load, current from the city and from the 2300-v. generator is supplied through the transformer bank to the station busses at 220 v. This arrangement is shown diagrammatically in Fig. 9. Two watt-hour meters fitted with ratchet arrangements furnish an accurate record of all current delivered to or received from the public service company.

Compressed Air

Compressed air for use in the factory is generated by a direct connected motor driven air compressor, installed in a separate brick building, located near the boiler room. This compressor is of the single stage type with three vertical cylinders having single acting pistons of the trunk type, and has a capacity of 300 cu. ft. of air per min. The compressed air is delivered into a 5 by 10-ft. receiver in which the pressure is maintained constant at 90 lb. per sq. in. by an automatic governor.

The machine is self-contained and is entirely automatic in operation. The automatic feature even extends to cutting off the cooling water supply when the machine stops.

A 50-hp., 220-v., 3-phase induction motor controlled by a rheostat is direct connected to one end of the compressor crank shaft. The rheostat, which is automatically operated, is employed in starting the motor and is

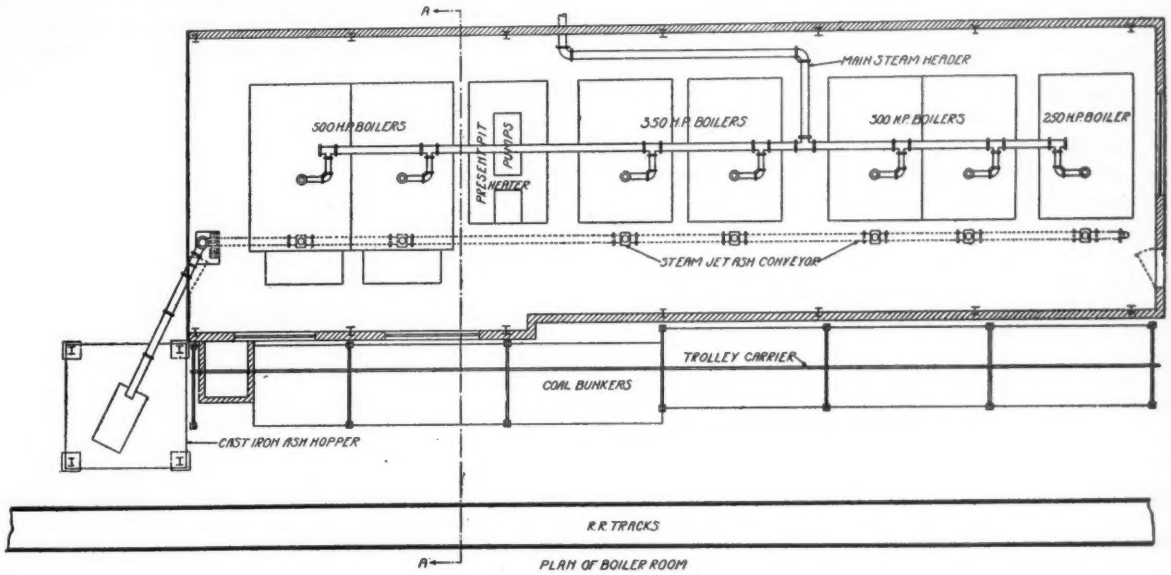


FIG. 8. PLAN OF BOILER ROOM

connected in the secondary circuit of the induction motor and has no direct electrical connection whatever with the primary circuit. An automatic unloader unloads the compressor at starting so that the motor starts with

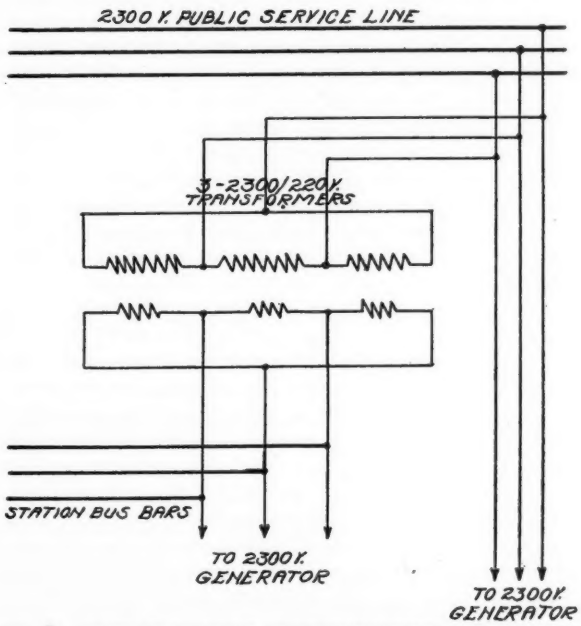


FIG. 9. DIAGRAM SHOWING INTERCONNECTION WITH PUBLIC SERVICE COMPANY LINES

virtually no load, the load being placed upon the compressor after the automatic rheostat is cut out.

Considered as a whole, the outstanding features of this plant are its simplicity and the excellence of its design and construction, considered from an engineering standpoint. Correct attention to the smaller details of the plant has resulted in eliminating many of the usual operating difficulties and has reduced maintenance expense and labor to a minimum. All piping throughout

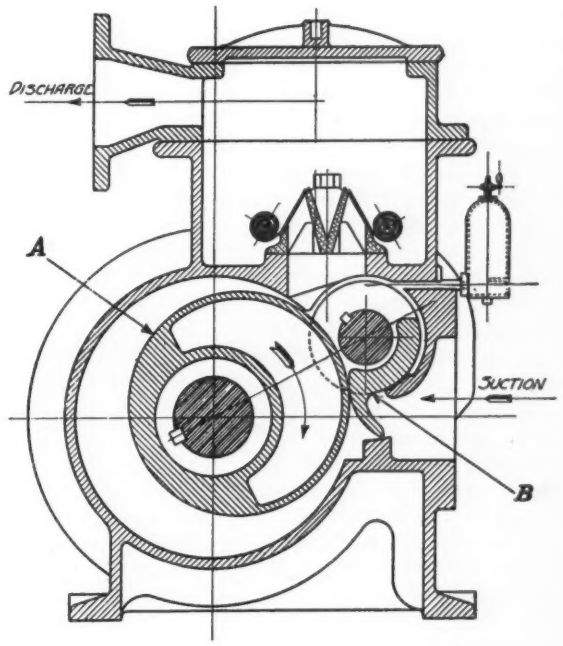


FIG. 10. CROSS SECTION OF ROTARY VACUUM PUMP

is as simple and direct as is possible to make it, and everything is solidly constructed with a view to permanency.

Much of the data as well as photographs used in the preparation of this article was secured through the assistance of J. P. Cashman, vice president, and R. Riggs, chief engineer of the company, to whom credit is hereby extended.

Trend of Power Industry in Buying Markets

CONDITIONS WHICH ARE AFFECTING PURCHASE OF POWER PLANT EQUIPMENT IN FOREIGN COUNTRIES. BY L. W. ALWYN-SCHMIDT

DISORGANIZATION of the public and private finances in Europe has led during the last few years to a systematic starving of all enterprise outside of Europe requiring the financial support of the European money centers. Africa, South America, Asia and Australia have suffered alike under this condition and only partial relief was brought by local financiers and domestic public loans in a few cases. The United States, which might have given financial aid, has also been backward in using this excellent opportunity of entering non-American power financing with the result that during the war at least progress has been comparatively slow. With the return of peace, financing conditions have improved without bringing forward, however, the popular support of foreign enterprise that would have been desirable, and only during the last three or four months Europe has been able to take a more intelligent interest in power matters outside of Europe. The cause of this situation was principally the complete breakdown of the international systems of credit and the general insecurity that has been one of the results of the Paris Treaty. Far from being satisfactory to the investor, this treaty has made his position still more insecure than before the war. With the treaty sanctioning practically the vast confiscations of private enemy property in foreign countries private investors ask themselves with justice, what security they have against a similar fate in case this country should lose a war in which it might become involved. Under such circumstances it will take considerable time before private capital can be made available for foreign financing and, pending some official lead in this matter, most of the money that will be spent during the next few years upon power development in other countries will have to come from the citizens of these countries themselves.

This insecurity also has a considerable influence upon the supply of power house material. In pre-war times, it was a general rule that the country giving the money would also supply the largest part of the equipment. Financing used to go hand in hand with manufacturing. If now foreign money can not be had any more, or if domestic investors will not place their savings into foreign enterprises, the national industries naturally lose much of their former business. There are, of course, countries which are unable to build their own power house and other power equipment. These will have to continue buying abroad. But they will not now place their orders according to financial considerations; the business will go to the most successful competitor, which is the firm that can give the best value for the money. If American finance should not come forward and support the American power-house industry in this respect, there is danger that much of the business gained during the past few years may be lost again.

Hence we have some cause to admire the foresight of English political enterprise which has combined so perfectly business with politics by building up, not only a large empire, but making this empire increasingly the Englishman's field of enterprise. English financiers at least will be secure in placing their surplus capital in the British Colonies and in doing so they will help to bring to the British electrical industry that business which we can gain only by running the risk, already mentioned, of losing the money of our investors whenever we should become entangled in any international political disturbance.

The financial conclusions of the Paris Conference have been hailed by France and England, the most important colonial powers of the world. The American industry, however, has less reason to be satisfied with the results.

But whatever diplomacy may have done to hinder financial enterprise, the world can not wait indefinitely for the Economic Council and the various other deliberative bodies set up in Paris. It has to go on with its everyday business and it has to provide the power for moving its machinery. South America, Asia, Australia and Africa, all having fallen behind in their power resources during the last six years, are busy now to make up for the loss of time as well as possible.

The French, having settled down definitely in Morocco, have erected a little power plant in Tangier, having a power development of 1000 hp. and 50 men. Of more importance and of wider aspect is the harnessing of the Ripon Falls in Uganda, Africa, which is contemplated by an English syndicate. The Ripon Falls are situated on the northern outlet of the Victoria Nyanza, leading the waters of that lake to the upper Nile. The average quantity of water passing over these falls is 20,000 cu. ft. per sec. and the power of the station could be strengthened by using a number of smaller supplementary falls above the principal drop. Uganda has made enormous progress during the last few years under the influence of the English colonial government and a large power plant in this location would find plenty of business carrying lighting and power to Kampala, Entebbe and other parts of the district.

AUSTRALIAN POWER CENTERS VERY ACTIVE

THE MOST active field of power development in the British Empire at the present time, no doubt, is Australia and New Zealand. It is industrially of special interest to the American power industry because the Australian governments and municipalities have in the past given American firms the fullest chance to compete and have even extended preference to American equipment in cases where prompt delivery could be guaranteed by the American makers. One of the large projects at present under way in Australia is that of the State of Victoria where tenders were called for a large quantity of electrical equipment for the new State Morwell Power Scheme which includes a 50,000-kw. steam turbo generator station and a 90-mi. three phase 132,000-v. transmission line with terminal substations. The total cost of all the material required for this purpose will run into many millions, of which $10,000,000 approximately have been appropriated already to make a beginning

with the work. At Albury in New South Wales, a power plant will be erected generating electricity from the Murray River for the transmission of power to the border districts of New South Wales and Victoria. That the business of manufacturing electrical power is a well paying one in Australia, by the way, is shown by the fact that the Adelaide Electric Supply Company, which is a private enterprise, has paid a dividend of 12 per cent for two consecutive years, which is not bad at all for an enterprise having a gross revenue of $800,000 approximately during the year.

Some interesting facts concerning power development in Victoria in Australia were contained in an article of the London Times, published in a recent issue of Commerce Reports. It appears that the Melbourne Metropolitan area is served by two power stations, one of which belongs to the municipality. These two power houses will have reached the limit of their capacity by the end of the present year and an additional supply of 10,000 kw. will have to be supplied from the power house of the Melbourne suburban railroad system. The Morwell power house project, mentioned already above, will help to relieve the pressure upon power production in Victoria.

There are large coal reserves in the proximity of the site for this new power house, holding approximately 150,000,000 tons of brown coal or enough to sustain an output of 100,000 kw. for 150 yr. to come. If this coal should give out, more can be found by making use of the large lignite resources of the district. The brown coal will be burned under the boilers without previous drying which will make necessary a special boiler equipment. The operating cost of this new plant is estimated far below the present cost of operating the existing plants in Melbourne and a saving of $60,000 is expected alone upon the business done by these two plants from the new enterprise.

To supplement the large coal power station, it is proposed to connect with it a large hydroelectric station at the Kiewa River, mentioned already several times in former reports on this place; 35,000 kw. are available from this source. To secure uniform control and execution of the whole enterprise, the State of Victoria has appointed Lieut.-Gov. Sir John Monash as a virtual dictator of the whole work, much as Colonel Goethals was put in charge of the Panama Canal work by President Roosevelt. His work will consist in the development of the coal mining operations, in briquetting and providing a public supply of coal, in constructing railroad communication, designing and constructing the power house transmission lines and other work connected with the project, and to conduct all other work that may lead to a successful execution of the plan. He will be supported in his work by the State Electrical Commission of which he is the permanent Chairman. The commission is a legislative body instructed with the administration of the light and power act and exercises absolute control over all State and other electric undertakings.

The effect of the new financial situation of the world and the resulting necessity of doing as much as possible without outside assistance is fully shown in the case of this large undertaking, as it has been specially stipulated that all work that can be done in Australia shall be executed there. The government, in consequence, is urged to use the present opportunity for the encouragement of an Australian electrical industry. Preference is to be given to English equipment in cases where this can not be made in Australia, but former experience has shown that American equipment is also not unwelcome to the Australian governments. It is said that a large part of the order for cables amounting to $1,200,000 approximately will be placed outside Australia.

New Zealand Extends Power Supply

New Zealand probably is still further advanced in power development than the Australian continent, having started its present policy of national development somewhat earlier. The Lake Coleridge development, which was the pathmaker in large hydroelectric construction in New Zealand, is now followed rapidly by a number of similar enterprises, of which tenders are just now invited for two 3000-kw. units that will find employment in connection with the Lake Monowai development, near Invercargill, in the Southland. This station will have a development of 18,000 kw. units when ready. The new station will serve a mixed farming and industrial country. The present plan of handling the distribution provides for governmental sale of power to the farmers and bulk sale to the municipalities if the latter should prefer to handle the business themselves. It is proposed to take up a loan of $7,500,000 in England, if obtainable, and to place the orders for the equipment also in England. In view of the great experience of the American industry of constructing large hydroelectrical power stations, it is, however, suggested that American firms might compete successfully after having also obtained orders for the Lake Coleridge plant some years ago.

New Zealand employs today 50,000 hp. of its available hydroelectrical power. The two largest stations are operated by the state, 14 others belong to municipalities and only five are private enterprises. It is estimated that 1,250,000 t. of coal, or half of the present requirement of the dominion, might be replaced by water power at a total installation cost of $100,000,000 approximately. The state exerts control over the national water powers by means of a number of local district boards, which will be augmented in the near future by a properly constituted hydroelectric advisory board of engineers and others. The national power plant at the Lake Coleridge which had been given up by the original promoters and was taken over and completed by the government as an emergency measure is operating now with a profit. During the last year, the plant which is constructed for the development of 8000 hp. worked with an average of 9240 hp. and sold 33,000,000 units of electrical power at a total cost of $223,036; the operating cost amounting to $205,590 including depreciation interest, a clean profit of $17,446 was made on this plant.

Turning to other power centers in the East, the situation in Japan calls for the attention of American power engineers and exporters of power equipment. Japan has not quite recovered yet from the severe economic shock it received as one of the after-effects of the war. The Japanese electrical industry, of course, has suffered along with the rest. To counteract the influence of this depression, it has now been decided to combine

several of the large electrical power stations, making them interdependent financially and technically, if possible, so that they may support each other if required. Three of the largest plants in the western section of the main island have been amalgamated in consequence, as is reported in an English-Japanese journal, and two others are expected to join the new group in a short time. The capital involved in the merger is given with 100,000,000 yen. The desire to give work to the Japanese electrical industry during a time when it is very much required also may have hastened the decision of the Japanese government to electrify its railroad system. This will lead to a considerable reduction of the steam locomotives and will bring orders amounting to 200,000,000 yen approximately to the Japanese electrical equipment makers.

Additional Power Required in China

Industrial expansion is the cause of a considerable increase in the demand for electrical power in China. As the result various new electrical central stations have sprung into existence while others have increased their distribution facilities. There are in use today in China also a large number of smaller private power plants, steam and electrical, which in a few cases sell electrical power to other consumers. It is said that the Chinese purchaser of electrical equipment is a quality buyer, which fact has given great prominence to American power equipment in that country.

The electrification of the suburban railroads of Rio de Janeiro is progressing very favorably now that a beginning has been made, bringing much business to the electrical industry in Brazil. Progress is also made with the plans of electrifying the Chilean railroads. Bids for furnishing the electrical power for the first zone of the state railroad are now invited. This covers the distance between Valparaiso and Santiago. American enterprise at the present time is largely responsible for private power development in South America. Especially the mining industry is requiring much new power equipment. An American company secured water rights on six rivers for installing hydroelectrical power stations in Bolivia. Water power is comparatively easily found in Bolivia, where rivers with medium sized falls are frequent. The power question is just now very much alive all over South America, owing to the increase in all industrial activity and the lack of coal and other industrial fuels.

Steam Stations for Hydraulic Relay Service*

Consideration of Design Factors of the Various Types of Supplementary Power Schemes Available. By E. B. Powell

SUPPLEMENTAL power in some form is an essential to the commercial development of our remaining unused Eastern water powers and, with the possible exception of the Niagara-St. Lawrence system, an essential to the further development of such of these water powers as are now utilized in part. The nature and extent of this supplemental, or relay, power will be governed in a large measure by the character of the stream and the amount, character and location of the load and the importance of continuity in power supply.

In many instances, the required relay, at least sufficient for the initial development, may advantageously be provided in the stream itself by adding reservoirs, or merely pondage, to give some artificial control of the flow. In other instances, the electrical interconnection of water power systems, so pooling the water resources of dissimilar streams, may also afford sufficient initial relay in hydraulic power. In general, however, the fullest commercial utilization of water power can only be had by the aid of independent relay, which in the greater part of the country today is most satisfactorily and economically provided in the steam power station.

Two General Types

Capacity and design of such a relay station should be decided as closely as may be by the particular functions it is intended to perform. The functions of the relay while they may vary widely, are of two general types, flow or head deficiency make-up and emergency reserve, the second being supplemental to the first. For either type of service, the capacity required in any particular case will depend upon the amount and characteristics, initial and prospective, both of hydraulic development and of load. The design, while broadly determined by the usual factors, such as location, power market, water and fuel supplies, fuel costs, which control in the case of the independent central station, is in general, on account of the commonly low load factor, less dependent upon considerations of operating economy. On the other hand, character of load and dependability of delivered hydraulic power are factors of prime importance and, for proper realization of the economic possibilities of the development as a whole, the design should also be governed in many important features by the characteristics of the hydraulic development and the relation of that development to the load.

Flow or Head Deficiency Type of Relay

Considering first the station intended solely to make up the power deficiencies of the hydraulic development, its functions may include any one or more of the following: seasonal operation to make up deficiencies in hydraulic power from low water or flood; absorption of load growth between stages of hydraulic development; operation as the main source of power. As reflected in the functions of the relay station and as affecting its design, hydraulic developments may be grouped as of four general classes:

I. Minimum Flow Development: Developed hydraulic capacity equal to or exceeding maximum system load. Resultant minimum available flow only slightly, and for brief period in the year, below corresponding load requirements. Reserve provided in hydraulic station.

II. Medium Flow Development: Developed hydraulic capacity equal to or exceeding maximum sys-

* Paper presented at joint meeting of Boston Sections of the A. S. M. E., the A. I. E. E. and the Boston Society of Civil Engineers, Feb. 7, 1921.

tem load. Resultant minimum available flow below load requirements for considerable period, 40 per cent or more, of the year. Reserve provided in hydraulic station.

III. Continual Relay Development: Available hydraulic capacity slightly below system load requirements throughout greater part of the year.

IV. Supplemental Development: Hydraulic development merely an adjunct to the steam power station, which carries the bulk of the load.

The type of reserve referred to in Classes I and II is for relay against failure of equipment within the hydraulic station itself. Under the conditions outlined, this reserve may often advantageously be installed as part of the hydraulic station rather than in the steam station. As is well known, from 50 to 75 per cent of the cost of the average hydraulic development is fixed and independent of the capacity installed, so that sufficient capacity for this type of reserve may frequently be included at comparatively low unit cost.

Effect of Load Growth

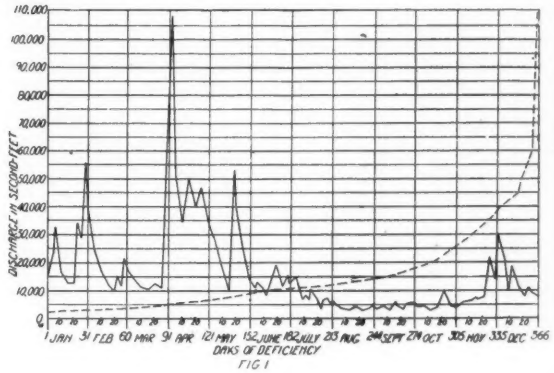
Usually conditions represented by Classes I, II and III are merely stages in approach to those of Class IV. This is especially true in the East. The change in relative status of the hydraulic and steam power stations may be slow, however, particularly so where a series of hydraulic developments may be brought in successively, as warranted by load conditions; in which case to pass beyond the conditions of Class II may require a matter of decades. For these reasons the entire project should be studied broadly in the beginning, both as to the ultimate physical possibilities and limitations of the hydraulic development, or developments, and as to the character and probable growth of the market for power. Neglect of such basic analysis in the initial planning of the development risks serious financial loss either in investment or in operating costs.

Seasonal Variation of Flow

Seasonal flow of the Hudson River in New York is so variable that the hydrographs of two successive years, 1915 and 1916, with their corresponding deficency curves may be used in illustrating developments of all four of the classes just referred to. In Fig. 1, it will be seen that if this hydrograph is assumed to represent the year of minimum flow for a particular stream and if a flow of about 3000 sec. ft. would supply the maximum power requirement, a development providing proper equipment reserve at this flow would approximate the conditions of Class I. If growth of load raises the daily power demand above the capacity of the available minimum stream flow and this growth of load is accompanied by a corresponding increase of generating capacity of the hydraulic station to utilize say 8000 sec. ft. to 10,000 sec. ft., with proper reserve, the conditions become those of Class II. Turning to Fig. 2, development of the hydraulic plant to utilize a flow of any 10,000 to 12,000 sec. ft. with daily load demands somewhat in excess of the mean available flow, would give the conditions of relay service under Class III. Continued growth of load with a single hydraulic development as applied to either type of stream flow will ultimately bring about the conditions of Class IV.

Reservoir Storage and Pondage

Of course, in the case of many streams, it would be feasible to provide sufficient reservoir storage to smooth out the stream flow to a material extent, thus raising the minimum or primary capacity of the potential development beyond the maximum load demands considered above under Classes I and II and at least, and possibly beyond that considered under Class III. For purposes of the present discussion, however, reservoir storage, as distinct from pondage in the usual sense, will not be further considered, as the effect of adding reservoir capacity in the development will introduce no new conditions of relay service distinct from those applying



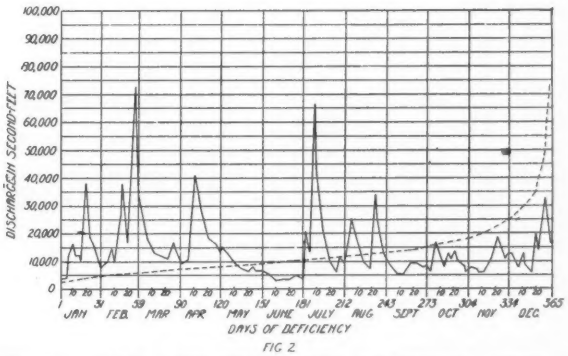


FIG. 1. DAILY HYDROGRAPH AND DEFICIENCY CURVE—HUDSON RIVER AT TROY (N. Y.) DAM, 1916

FIG. 2. DAILY HYDROGRAPH AND DEFICIENCY CURVE—HUDSON RIVER AT TROY (N. Y.) DAM, 1915

under the four groups discussed, but may merely shift the development on the scale of the present classification, or possibly remove the occasion for independent relay, from a capacity standpoint. Pondage, on the other hand, does not affect the seasonal variation of the stream; it provides regulation of the daily flow.

Effect of Pondage

The effect of pondage upon the relay station requirements may be judged from reference to Fig. 3 which shows a typical manufacturing town load with the "per cent load" curve superimposed for convenience of interpretation. If the minimum flow is assumed equivalent to 50 per cent of the day's energy requirement, with full 24-hr. pondage provided, the hydraulic station could take off the upper 70 per cent of the demand,

permitting the relay station to carry the base load at a daily load factor approximating 90 per cent with a demand only 30 per cent of the total. On the other hand, in the absence of pondage, the relay station must be designed to carry about 7 per cent of the total demand and on this basis its daily load factor would be reduced to about 40 per cent. It is apparent that, in the absence of pondage, higher capacity will in general be required in the relay station and the relay station load factors, both daily and annual will tend to lower values than where full pondage is provided.

Relay Station for Minimum Flow Development

Referring again to Fig. 1, it will be seen from the deficiency curve that, if the maximum load demand is

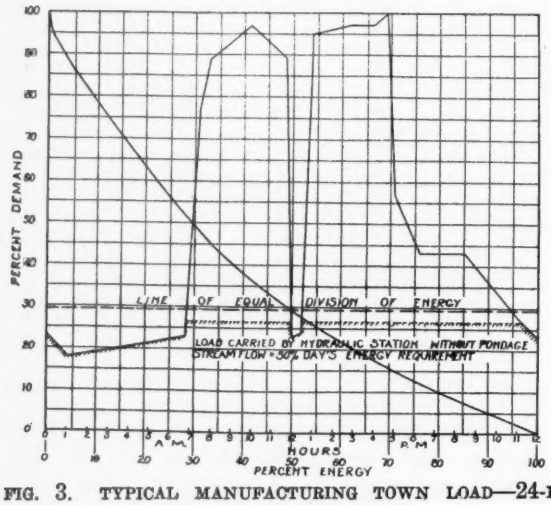


FIG. 3. TYPICAL MANUFACTURING TOWN LOAD—24-HR. LOAD FACTOR, 53 PER CENT

within the capacity of the 3000-sec.-ft. flow which is the developed capacity considered for Class I, the relay station except for conditions of equipment failure should not be called upon for operation in excess of 5 per cent of the year. It is not uncommon for relay stations under such conditions to stand idle an entire year. Obviously, for service of this character the actual operating economy of the relay station is of relatively small moment. The important considerations are low fixed costs and dependability.

As the load demands increase and the operating conditions for the relay station approach those of Class II, steam power production costs are of slightly greater moment but in general are still tremendously outweighed by fixed charges and other costs independent of production. Usually, it is only when the conditions of Class III are reached that the annual load factor of the relay station has risen to a value sufficient to make fuel economy as such an important factor in design.

For the extremely low load factor conditions of Class I, type of equipment, dimensions and arrangement must all be studied with a view to attaining the desired output with minimum investment, compatible with simplicity of station and low cost of attendance. Type of combustion equipment and the arrangement of furnace must, of course, be governed by the character of fuel available. Oil is the ideal fuel for any type of steam relay station but is not widely available commercially in sufficiently dependable supply. At the present stage of development, pulverized fuel involves a greater degree of complication than is usually warranted in the station designed for the extremely low load factor conditions of this case. Coal in its more ordinary form will in general be the most satisfactory fuel. The stoking equipment should be of the forced draft type for high capacity, either underfeed or chain grate, depending upon the class of coal. Draft facilities should be designed to take care of the maximum rate of combustion that can safely be maintained by furnace and grate over the period of peak load on the station. Economizers cannot be justified for the conditions of Class I, but it may be advisable to make provisions for their later installation to meet higher load factor conditions in the future.

The selection of type and size of boiler, decision as to total boiler capacity to be installed, and the proportioning of combustion equipment to boiler heating surface must take into account not merely the cost of that equipment only, but also the costs of building and all related equipment such as fuel and ash handling facili-

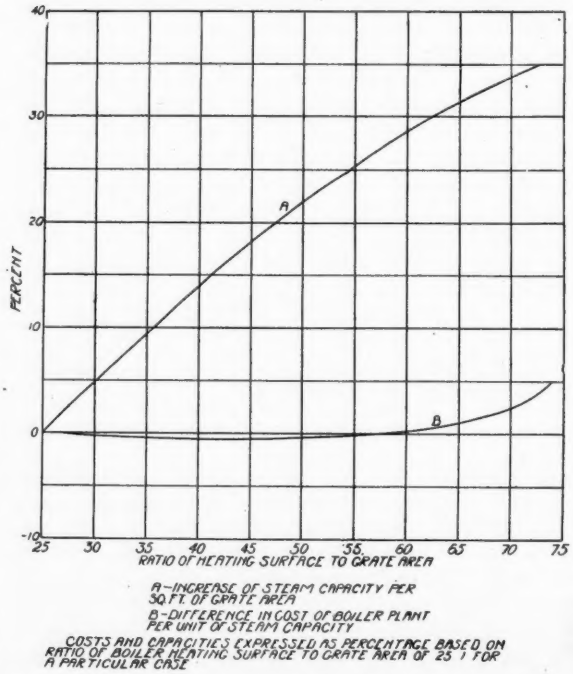

PERCENT
A
B
RATIO OF HEATING SURFACE TO GRATE AREA
A—INCREASE OF STEAM CAPACITY PER SQ. FT. OF GRATE AREA
B—DIFFERENCE IN COST OF BOILER PLANT PER UNIT OF STEAM CAPACITY
COSTS AND CAPACITIES EXPRESSED AS PERCENTAGE BASED ON RATIO OF BOILER HEATING SURFACE TO GRATE AREA OF 25 : 1 FOR A PARTICULAR CASE

FIG. 4. BOILER PLANT CONSTRUCTION COST AND CAPACITY AS AFFECTED BY RATIO OF BOILER HEATING SURFACE TO GRATE AREA

ties, and mechanical draft. The cost curve, Fig. 4, shows that, for the particular case considered, when all related factors are taken into account boiler heating surface may be installed to the comparatively high ratio to grate area of 50 : 1 without appreciable increase of total boiler plant cost. Higher ratios are accompanied by some increase of cost. The use of a lower ratio will result in needless waste of fuel.

Equally broad considerations should be applied to the design and proportioning of the condensing equipment. Considering the net increment cost of the boiler plant per unit of effective steam capacity and the incre-

ment cost of condensing plant for unit change of vacuum at the turbine exhaust, the condensing equipment should be designed to give the degree of vacuum under conditions of the required maximum load which will result in the lowest construction cost for the plant as a whole. In Fig. 5, the curves show, also for a particular set of conditions, at "A," the relative construction costs for condensing equipment to attain different degrees of vacuum, the cost of the 29-in. design being taken as 100 per cent; at "B," drawn to the same scale, the increase in boiler plant cost resulting from the increased total steam demand which is had from different degrees of vacuum less than 29-in.; and at "C," which is a summation of "A" and "B," still expressed in terms of 29 in. condensing plant cost, the resultant effect upon total station cost, of designing the plant for different degrees of vacuum.

These two charts, Figs. 4 and 5, are correct, as to detail, for the particular conditions only for which they were estimated; but they clearly illustrate the interdependence of equipment costs and the importance of taking all related factors into account in deciding upon the type and size of apparatus. Similar considerations should be applied to the selection of generating units and to the determination of steam pressure and temperature.

Instrument equipment for mechanical apparatus such as boilers and condensers should be complete in so far as required as guides to efficient combustion, and to the attainment of the highest degree of vacuum of which the condensing apparatus is capable; not that efficiency in the sense of low fuel rate is of special importance in this service, but that it is an essential to the attainment of maximum output from the major equipment installed, which is the prime purpose of the station design.

It will usually be found advantageous to provide electric drive for one complete set of essential auxiliaries to permit starting these without waiting for steam. The main electrical features of the relay station for the Class I conditions will be governed largely by the relation of the station to the rest of the system, provision being made to compensate for line or load characteristic wherever required. Special emphasis, however, should be placed upon simplicity and ruggedness in construction and upon low attendance requirements, particularly for non-operating periods.

Relay Station for Higher Load Factor Conditions

As the system load grows, if the period of relay station operation is permanently lengthened, taking the development into conditions of Class II for example, the higher load factor on which it may be possible to operate any new equipment may justify greater consideration of actual operating economy, condensing equipment may be of more liberal design; boiler capacity may be added in greater ratio to steam demand, so permitting reduction of combustion rates.

Further growth of load and extension of the operating period for the relay station into the conditions of Class III will justify in new equipment still further consideration of operating economy, until, as the conditions of Class IV are reached, practically the same factors govern as in the usual independent type of central station.

As may be inferred from this outline of the progressive extension of the relay station to keep pace with the system's requirements, the relay station properly designed for low load factor conditions may be readily converted to a high load factor station, and so converted should operate as such with but a fraction higher total costs than the station specially designed for the higher load factor. The reasons for this are chiefly: First, boilers and furnaces properly designed for Class I relay service are of efficient type; they are merely driven to extreme ratings under the low load factor operation; as loading conditions warrant, the ratings are reduced, bringing into evidence the higher fuel economies of which the design is capable, also lowering maintenance expense per unit of output. Second, in general, the Class I low load factor relay station should include no

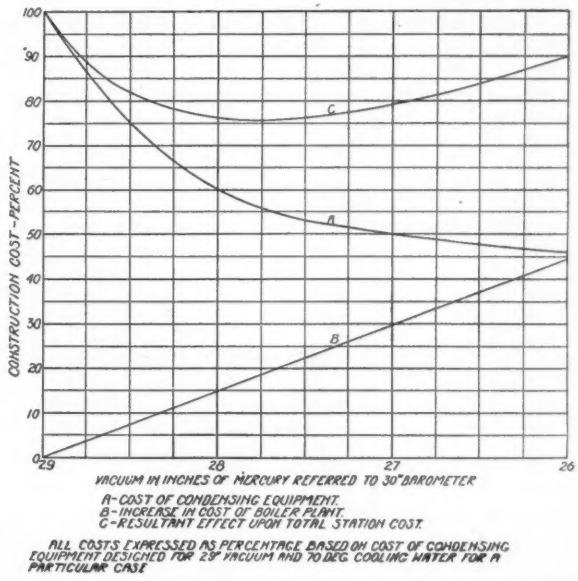


FIG. 5. RELAY STATION CONSTRUCTION COSTS AS AFFECTED BY CAPACITY OF CONDENSING EQUIPMENT

reserve capacity in generating units beyond that actually required to carry the anticipated maximum demand; growth of load factor to proportions where operating economy becomes of importance in design, even though unaccompanied by growth in demand, will call for the addition of reserve equipment as a measure of insurance; the new unit with its auxiliaries may be designed for whatever degree of economy is warranted and may then be operated to take the base of the relay load. Third, as warranted by conditions, more efficient auxiliaries may be introduced for the older units, as for example, larger capacity and more efficient circulating pumps on the condensers and, where spray ponds or cooling towers are employed, increased cooling capacity.

Figure 6 shows the power costs from two types of station operating on the same conditions of load. Station A is designed initially for relay service under Class I conditions. Improvement in load factor is accompanied by the installation of such additional equipment and of such economic characteristics as may be warranted. Station B is designed for continuous operation at 50 per cent annual load factor. Its first cost is nearly 50 per cent higher than that of the initial step of Station A and,

while more economical at the load factor for which it is designed, on the lower range of load factors the higher efficiency of its equipment is insufficient to balance the higher fixed charge. Accordingly, where there is doubt as to the actual load factor at which the relay station may be called upon to operate, it will in general be advisable to design for the minimum probable load factor rather than risk unnecessary expenditure in providing for load conditions that may require years to attain.

If the fundamental design is right, the initially high operating charges characteristic of the low load factor station are readily outgrown whereas the fixed charges, essentially higher for the high load factor station, are inescapable and remain until amortized, a permanent burden on the development.

Emergency Reserve Type of Relay

The service required of a station which must also function as an emergency, or break-down reserve, may

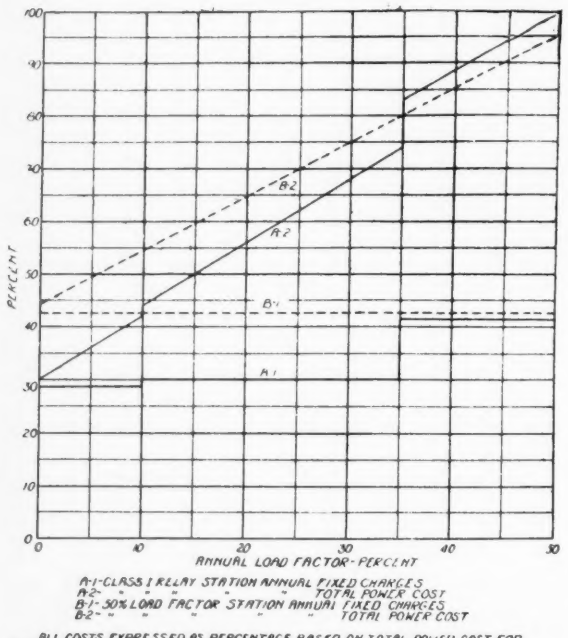


FIG. 6. ANNUAL POWER COSTS OF STEAM RELAY STATION AS AFFECTED BY LOAD FACTOR FOR WHICH PLANT IS DESIGNED

vary from floating capacity for instant availability to merely providing against interruptions of several hours or days. The requirements in any particular case will be governed in a large measure by the character and importance of the load served.

Miscellaneous power service and lighting should, in general, be completely relayed against more than momentary interruption; for some classes of power, frequently that applied to electrolytic processes, for example, longer interruption of service is not of so serious moment, not sufficiently serious to warrant the expense of full relay; on the other hand, an extensive d.c. network, such as that in large metropolitan cities, must be absolutely safeguarded against interruption, however brief.

When the steam relay station is to serve as an instantaneously available reserve, the necessary excess capacity in generating units must be maintained on the line and actually under steam at all times. Station design to provide most economically for such service must afford, for minimum investment, a maximum of flexibility in capacity, with minimum standby charges. Characteristics in equipment peculiarly favoring these requirements are:

1. Combination electric-steam drive on the larger auxiliaries, such as circulating pumps and mechanical draft fans, for the units operated as floating standby;
2. Turbo-generating units with direct driven exciter, and with overspeed controlled steam bypass for turbine blade cooling independent of normal governing valves;
3. High ratio of turbo-generator capacity in comparison with point of lowest water rate;
4. Wide flexibility with quick response in control of boiler output and rate of combustion;
5. High ratio in capacity of combustion equipment vs. area of boiler heating surface.

The first two of the characteristics mentioned are of advantage chiefly where the steam station is used exclusively for relay; they tend to reduce the standby fuel costs by permitting the reserve units to float on the hydraulic system with but negligible consumption of steam. The importance of the third characteristic is particularly evidenced where the steam station normally operates as a generating station in parallel with the hydraulic station; the excess capacity may thus be carried in the units under load, without serious loss of operating economy. The two characteristics last mentioned, those referring to the design of boiler plant, are essentials to maximum service from the standby station under any condition.

Where commercially available, fuel oil with mechanical atomization is particularly advantageous on this class of service; its use permits the fulfillment of these boiler plant requirements to an almost ideal degree. With proper design, the response to control is practically instantaneous; capacity attainable is the highest of any commercial fuel. Oil fuel has the added advantage, particularly important in standby service, of minimum banking loss.

Pulverized coal, bituminous or sub-bituminous, for the larger plants, is only second to oil in flexibility of control and low banking loss. In general, the underfeed type of mechanical stoker, given proper ratio of grate area to heating surface will also fully meet the requirements in both flexibility and capacity. The banking losses are, however, necessarily higher than for either oil or pulverized coal.

The class of fuel to be adopted in any particular case should be governed by the local conditions of fuel market, load and relay station load factor, present and prospective, station location and capacity; however, it is usually true that fitness of equipment, and of its arrangement, for the requirements of the fuel determined upon, are of greater importance than the selection as to type of fuel.

Emergency relay service on loads for which absolute continuity is of less vital importance will normally involve actual readiness to serve only during periods of anticipated power deficiency such as between seasons

when stream flow is precariously near the actual load requirements and any slight diminution of flow will necessitate calling upon the relay station, or when there is possibility of sudden ice accumulation, or floods threaten curtailment of head.

For relay service of this character it will usually be sufficient to maintain a few boilers under fire and the larger of the essential auxiliaries turning over. The general characteristics of equipment outlined for conditions requiring instantaneous availability of the reserve apparatus will be advantageous in this case also. The combination electric-steam drive for auxiliaries may be omitted in the interest of first cost, as the relay is not necessarily intended to meet full failure of hydraulic power, but the provision of electric drives for one complete set of essential auxiliaries, as recommended for the normal deficiency makeup type of relay station to permit prompt starting of such equipment without waiting for steam, will usually be found particularly advantageous under the service conditions now considered. It may also under some conditions be advantageous to make use of electrical heaters in maintaining hot water circulation in certain of the boilers, instead of actually holding them under fire. Oil is again the ideal fuel, but it is questionable whether, in the average case, pulverized fuel will possess any advantage over the forced draft underfeed stoker. New developments may, of course, readily change the relative status of these two methods of burning coal. In general, the features of design which are specially advantageous for this type of relay are common to the instantaneous type of relay and are readily embodied in the station designed for the simpler type of makeup service.

Considering again the general characteristics and requirements of the steam relay station, the feature which should be regarded as secondary only to low construction cost and adequate dependability is that of low attendance requirements, and not merely for the non-operating period but for actual operation as well. With this object the design should tend to large units and, as far as compatible with thorough simplicity, to automatic control. Where feasible, combining the functions of distributing station with those of the hydraulic relay, assists materially in holding down both construction costs and attendance for the relay station. It should be borne in mind, however, that maximum returns on the investment in any type of steam power station can only be had through skilled and well trained operators. Such men cannot be picked up on a moment's notice. It is true that it is often possible during periods of plentiful water supply to distribute men from the steam stations through other departments, but the number of men that may actually be employed in this way is limited. Where men are held over long periods without really effective employment there is invariably loss of efficiency and of morale.

Recent Practice in Baffling Boilers

DESIGN OF BAFFLES INCREASES BOILER CAPACITY AND LENGTHENS LIFE OF FURNACE WALLS. BY KINGSLEY L. MARTIN*

FOR many years, there was a marked difference between marine and stationary boiler practice in developing excess rating from boilers. Where 10 sq. ft. of heating surface was thought necessary to develop a boiler horsepower ashore, the practice afloat was to allow only three or four.

The recent tendency in modern power houses has been to run boilers at from 200 to 300 per cent of rating and in some cases as high as 400 per cent for hours at a time.

Many engineers still think that this is "forcing" a boiler and must inevitably result in tube trouble and high maintenance cost. This is not necessarily so when the furnace is properly designed and the boilers properly baffled.

One of the first essentials is to have sufficient furnace volume so that combustion will be completed before the hot gases strike the heating surface. This can be accomplished by setting the boiler high (sometimes 20 ft. from the floor to the bottom of the front header) and by building the bridge wall as far to the rear as possible, or omitting it altogether.

In Fig. 1, the base of the bridge wall is located at the ash dump but racks back sharply until the face of the wall is 12 ft. 7 in. from the front. The lower part of the rear wall is omitted and a soot shelf resting on the bridge wall constructed. From the top of this wall a baffle wall slopes forward to a point halfway between the curtain wall and the front header. Figure 2 shows this wall in place.

*President of the Engineer Co.

This construction has the following advantages:

First: The bridge wall is back where it gets less direct heat from the incandescent fuel bed and less erosion from the hot furnace gases.

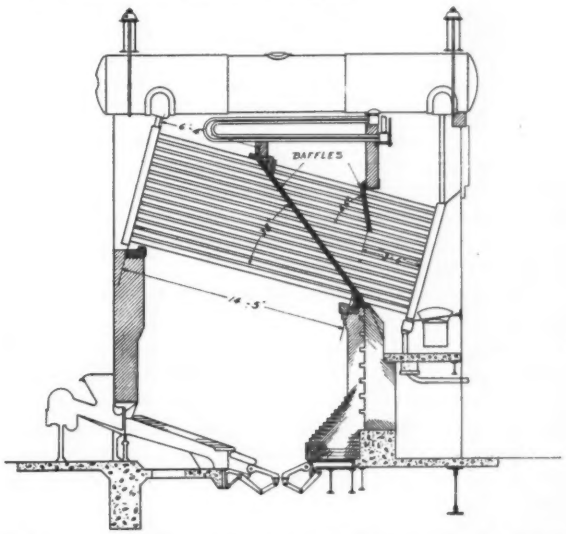


FIG. 1. JUG SHAPED FURNACE REFLECTING HEAT ON FRONT ENDS OF BOILER TUBES

Second: The wide mouth of the first pass exposes the maximum amount of tube surface to the radiant heat of the fire.

Third: The relative area top and bottom of the first pass are such that the shrinkage of the cooling gas is

provided for and the maximum capacity of the boiler may be developed without too high an entrance velocity of the gases.

Fourth: The low velocity of the highly heated gases through the first pass increases the rate of heat transfer which is directly proportioned to the time of the contact.

It has been found that the elimination of the short horizontal shelf on the lower row of tubes between the top of the bridge wall and a vertical baffle which is sometimes used, is also an advantage both from a maintenance and operating standpoint.

For instance, draft readings in the furnace have shown that under the horizontal shelf there is frequently a dead pocket where there is little or no circulation of gas and the still, soaking heat which results, is fatal to the furnace linings.

It has also generally been found that the reflected heat from a horizontal shelf strikes the exposed ends of the stokers after the fires are dumped and particularly so when the blower has slowed down for any reason at the same time. The result is the fusing of the ends and the burning of the dump plates.

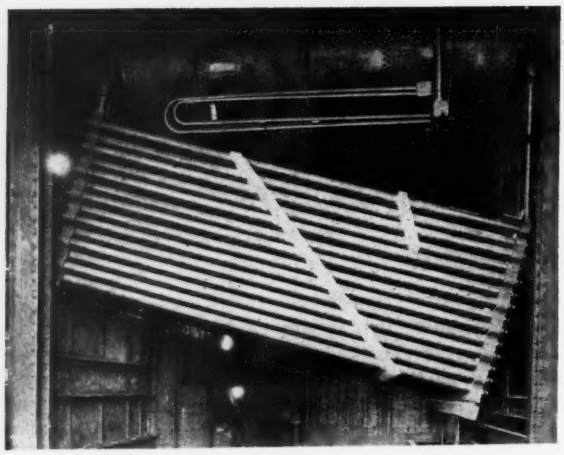


FIG. 2. COMPLETED BAFFLES DURING ERECTION OF BOILER

One of the most exasperating troubles in operating boilers at high ratings with certain coals is an accumulation of slag on the lower row of tubes which soon restricts the opening to such an extent that it is necessary to take the boiler off the line for no other reason than to clean off this accumulation.

The construction shown tends to eliminate this trouble for three reasons:

First: The wide opening of the throat reduces the velocity of the gases so that there is time to complete combustion and they do not pick up and carry with them the fine particles from the fuel bed to the same extent.

Second: The increase in area permits the slagging action to continue for some time at its reduced rate before the draft restriction becomes so great as to require taking off the line. In some cases on 1500-hp. boilers operating at 300 per cent of rating, this period has been extended from ten days to one to four weeks.

Another method of getting the same or even better results is shown in Fig. 3. Here the drop header construction permits the use of a short horizontal shelf on top of the second row of tubes and the accumulation of soot on the shelf can be removed from this shelf as it can not be from a shelf on tubes of the ordinary close spacing. In this design, both the lower rows of tubes are in the furnace chamber their whole length and exposed to the radiant heat. Doctor Jacobus says there is apparently no limit to the amount of heat that can be

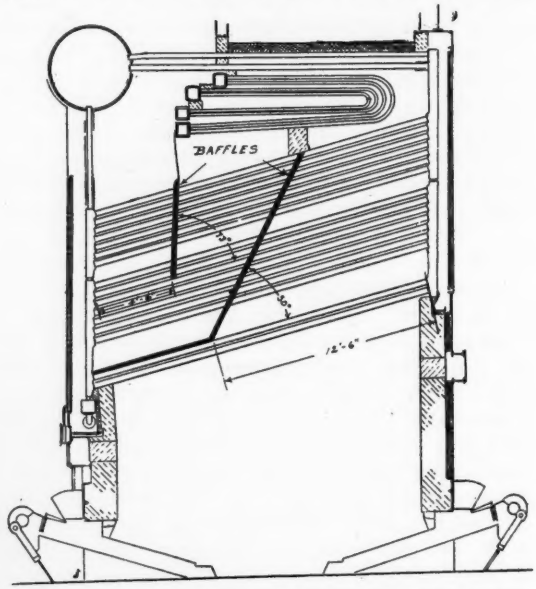


FIG. 3. BAFFLES FOR BOILER HAVING FURNACE WITH STOKERS ON BOTH ENDS

transmitted through a boiler tube provided it be kept clean both inside and out.

Much has been accomplished in the last 3 yr. in solving problems in furnace construction, where oil, tar or pulverized coal is used. In all three of these fuels the flame is terrifically hot and has a highly erosive action on any surface it strikes, and the preservation of tubes also requires that no blow torch action be permitted.

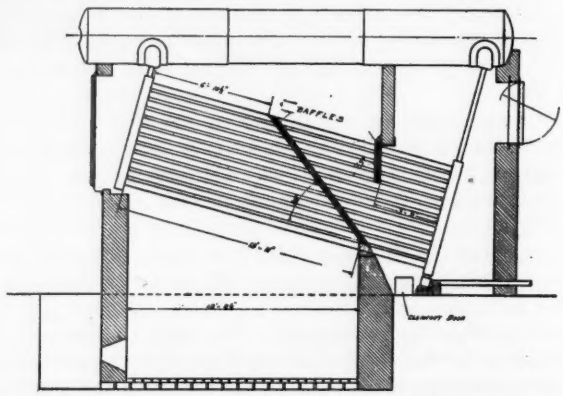


FIG. 4. BAFFLES FOR BOILER WITH TAR BURNING FURNACE

A construction similar to that shown in Fig. 4 has resulted in prolonging the life of bridge and side walls by months and in eliminating tube trouble altogether. The boilers shown were originally coal fired and may be changed back but are now burning gas tar. The use of the long sloping baffle has made possible the location of the bridge wall where the flame dies out before striking it, prevents the flame being turned up against the

tubes and materially diminishes the heat reflected back to the front wall and burners. The sloping wall at the foot of the bridge wall reflects much of the heat directly up to the tube surface above.

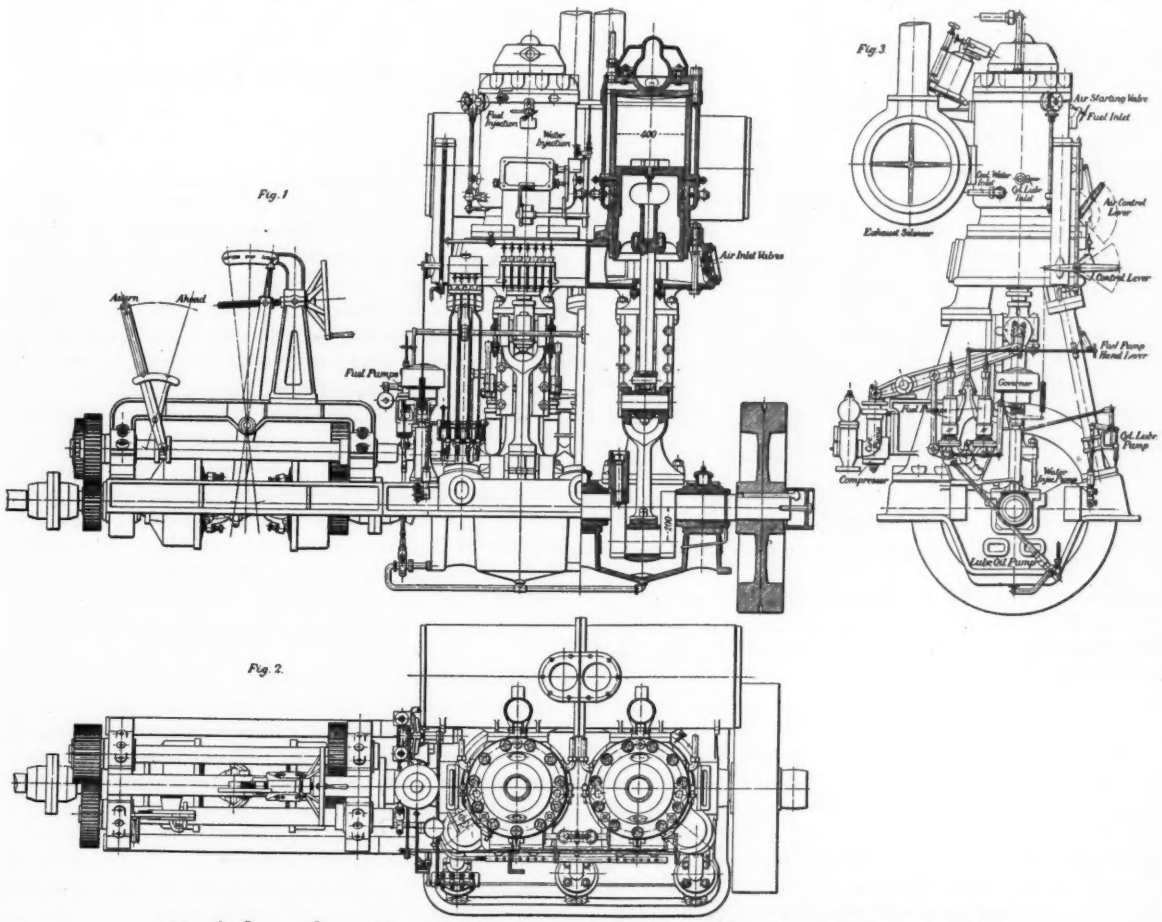
The construction of the baffle wall that has made these designs possible is of interest, as it is entirely new within the last 6 yr. It is built either before or after the side and bridge walls of the boiler are in place. Corrugated tile 4 in. wide are laid through the diagonal alleys between the tubes and a single form is placed on the front side of the wall. The space around the tubes and between the corrugated tile is then filled with a fireproof plastic material which is air hardening and does not bond either with the tubes or the tile. As a result, tubes can readily be withdrawn any time and replaced by others slipped through the same holes.

All the plastic material is placed and tamped around the tubes so as to fit them accurately no matter how bent they may be. The result is a gas tight wall. It can be built equally well at any slope as it is supported by the tubes and has no metal backing to overheat and force it out of place.

A New Semi-Diesel Engine

MARINE OIL ENGINE DEVELOPED IN HOLLAND POSSESSES FEATURES COMMON TO STEAM ENGINES

DRAWINGS accompanying this article which was abstracted from Engineering of London, illustrate an interesting type of marine oil engine which has been developed by the N. V. Machinefabriek "Bolnes" of Bolnes, Holland. As will be gathered from the illustrations, the engine is of the two-cycle, hot-bulb (or semi-Diesel), type, and a special feature of the design, which will be at once apparent is the resemblance of the general arrangement to that of a steam marine engine. It will be seen that the piston is fitted with a piston rod, and a crosshead working in a slipper guide of ordinary marine design is provided and coupled to the crankshaft by a forked connecting rod. The moving parts are thus not only of a design familiar to all marine engineers, but are also open and easily accessible for examination and adjustment. This arrangement has been rendered possible by compressing the scavenging air in the hollow cast iron columns which support the cylinders on one side, instead of in the crankcase, as is usual in this type of engine.



FIGS. 1, 2 AND 3. PLAN, SIDE AND END ELEVATION OF 130 B.HP. BOLNES OIL ENGINE

Bolnes oil engines are made in several sizes with one, two, four or six cylinders, developing from 10 to 600 hp., the example illustrated having two cylinders giving about 130 hp. at 240 r.p.m. As previously mentioned, the cylinders are supported on one side by two hollow cast-iron columns, which form the reservoirs for scavenging air, and are bolted to the bedplate as shown in Fig. 4. On the other side, the cylinders are carried by three turned-steel raking columns. It will be noticed from the cylinder sections, Figs. 1 and 4, that the piston is provided with six gas rings and two oil scraper rings. Figures 1 and 4 also show the design of the cylinder head and hot-bulb, the former being in communication with the water-jacket space of the cylinder. While referring to this part of the engine it will be convenient to call attention to the method of fuel injection. The fuel jet, as shown on the right of Fig. 4, is inclined upwards and the stream of oil from it

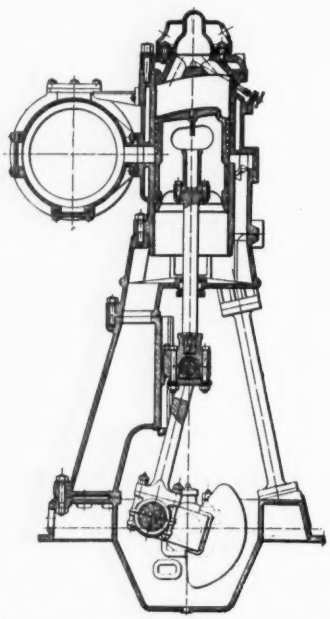


FIG. 4. SUCTION THROUGH CYLINDER

impinges on a small knife-edge of special alloy steel screwed into the cylinder head, the effect of the knife-edge being to break up the stream into a fine spray and so facilitate combustion.

Supplying Scavenging Air

Arrangements for the supply of scavenging air need but little explanation since they can easily be followed from the drawings. It will be seen that the lower open end of the cylinder is bolted on to a cast-iron chamber communicating with the hollow columns, the piston rod passing through a stuffing-box in the lower wall of the chamber. A passage from this chamber communicates with the scavenging port in the cylinder wall, as shown in Fig. 4. On the upstroke of the piston, air is drawn into the chamber through the valves shown on the right of Fig. 1, and the air is compressed on the downstroke of the piston until the latter uncovers the scavenging port, when air enters the cylinder and passes out through the opposite exhaust port, taking with it the residual exhaust gases. A hand operated valve is provided in the passage leading to the scavenging port to enable the scavenging air to be cut off when the engine is running light for a long period.

Lubrication

Cylinders are lubricated by two mechanical pumps shown in Fig. 3, which supply oil to the cylinders through connections on each side, seen just below the top of the piston in Fig. 1. All other important parts are supplied from a receiver through drip sight feeds, oil being delivered to the receiver by another pump which draws its supply from the bedplate sumps.

Water injection is used at full load, the water being supplied by a pump and entering the cylinder through a needle valve in the air passage leading to the scavenging port. Starting is effected by compressed air controlled by hand-operated valves and supplied from a small auxiliary reservoir. This reservoir is filled from the main reservoir, which is normally kept charged by the compressor on the engine, but a hand compressor is provided for charging the auxiliary reservoir in an emergency.

Diesel Engine Operation

Practical Hints on the Care and Operation of Diesel Oil Engines. By R. S. Malone

RAPIDLY increasing use of the Diesel engine for power purposes both in marine and stationary practice requires for its attendance an ever-increasing number of engineers familiar with the care and operation of this type of engine. The steam engine has been in use for generations and most engineers are thoroughly conversant with it. The Diesel engine, however, is comparatively new and unknown by engineers and requires special attention.

In the 15 yr. of the writer's experience in operating and erecting oil engines, many obstacles and operating difficulties have presented themselves which have been overcome with more or less difficulty and with more or less success. It is for the benefit of those engineers who are new at the game and whose experience in the Diesel engine field has been comparatively short, that the following suggestions are given.

Regulating Compression

To begin with, if an engine is of the multi-cylinder type, care must be taken to have compression equal in all cylinders in order to insure smooth regulation. This is of particular importance when operating alternating-current generators in parallel. Compression may be determined by means of an indicator.

An ordinary steam engine indicator can not be used with internal combustion engines, due to the high compression and the sudden shock which the indicator piston receives at the instant of explosion. Due to the high pressures met with in gas engine work, and to obviate the use of heavy springs, gas engine indicators are usually furnished with pistons of one-half the standard area, that is 0.25 sq. in. in place of 0.5 sq. in. It may be said here, however, that the use of an indicator is not as essential in oil engine operation as it is in connection with steam engines.

Compression cards are taken by attaching the indicator to a cylinder in the usual manner and then cutting out the fuel supply to that cylinder. Note only compression on the resulting card. If the engine is of the single cylinder type, bring the engine up to speed without load and when running smoothly cut off the fuel supply. Take the card as the engine is running from the force of the flywheel. There will generally be time enough to take two cards in this manner and should it be necessary to put the machine into service immediately, the lever can be thrown back into the starting position before the engine has come to a stop. It will then pick up speed the same as when starting normally.

Since combustion of the fuel in the Diesel engine is caused by the heat of compression, it is essential that such compression should not be less than 470 lb. per sq. in.; 500 lb. is to be preferred with most engines.

Compression may be regulated by the amount of clearance given to the piston, but avoid adjusting the piston each time compression falls off. Keep tight rings on the piston and give them careful attention. Furthermore, make certain that the rings lie loose in their grooves, since they often stick tight due to carbon. The latter condition is frequently caused by using too much oil in the cylinder or by using oil of inferior quality. Rings sticking from this cause sometimes break, causing great damage to the cylinder walls; the writer has had to rebore cylinders from this cause alone. Proper lubrication is of extreme importance in Diesel engine operation and should never be neglected. Do not experiment with cheap oils, use only oil that is fully recommended and indorsed by the engine manufacturers.

For cylinder lubrication use an oil, free from acids and animal matter having a flash point of not less than 500 deg. F.

All valves should be kept perfectly tight, as leaking valves will greatly reduce the compression and affect the economical operation of the engine.

Cooling Water

Operating procedure in regard to the cooling water is of extreme importance and the opinions of engineers vary greatly on this point. Contrary to the instructions of some manufacturers of oil engines, the writer, however, is of the opinion that the circulation of cooling water should be stopped at the time of stopping the engine.

When operating a plant in Texas several years ago, much trouble was encountered in the operation of Diesel engines and cracked cylinder heads were lying all over the premises. The same condition existed at a neighboring plant nearby. Upon adopting the practice of cutting off the water supply at the time of stopping the engine, the trouble disappeared and the writer has never cracked a cylinder head since.

Never interrupt the flow of water when the engine is running. If for any reason the water supply fails, stop the engines at once, thereby avoiding the danger of seizing the pistons and doing other damage. If necessary, let the lights go out or allow the plant to come to a standstill, but take no chances of running the engine for the sake of a few minutes' lost time. A few moments' time lost in this manner will save days of lost time incurred by a damaged cylinder.

In the event that the failure of water supply is unnoticed for a short time and that the engine has been run without water before stopping, allow the machine to cool off a bit before turning water into the hot cylinder heads. Failure to observe this procedure will surely result in cracked heads or ruined cylinders.

Inspection

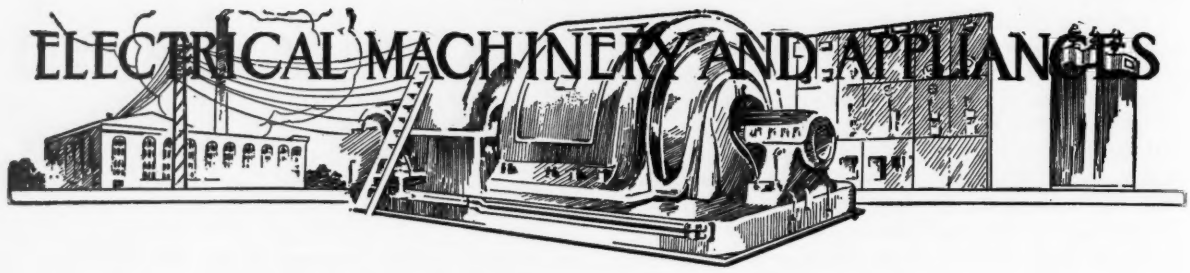
Make it a point to inspect and overhaul the engines periodically and on fixed schedules; for instance, work all the valves on one cylinder on a certain day of the week and on the succeeding days follow out the same procedure with each of the remaining cylinders. Inspect the pistons every 8 or 10 mo. and examine all rings at these times, putting in new rings where necessary. Take up on all bearings as conditions require and never allow the machine to pound. Keep a few extra fuel valve needles and gaskets on hand but don't acquire the habit of carrying a knocked-down engine in stock in order to keep one engine in service. This is bad practice and does not speak well for one's ability as an engineer; furthermore it puts the owners to considerable expense. Should a condition arise which cannot be mastered, write to the builders of the engine regarding the trouble. They will gladly extend their advice and if necessary will send an expert to correct the defect.

By close observation, any good mechanic should obtain good results with an oil engine if he is willing to give the machine a fair chance.

"Times Are Hard"

By C. Gilbert Norton

It seems to me that these are days in which there is far too much haze o'erhanging each man's business vision. Each blasted member of the globe thinks only of his natal robe when he must render a decision. He thinks: "How rotten things are! Wow! What will they be a month from now? * * I'd better slash the costs some more." He buzzes for the good P. A. "Buy nothing more, Jones. From this day kick every salesman out the door." Along this line he blindly goes regardless of whose head or toes he chops at as he swings the axe. But when the ledger costs are thin, in just the shape to make him grin—the whole shebang caves in and cracks! A boiler tube, chock full of scale, blows up and all hell seems to hail. (That's going to cost a lot o' coin.) * * Then later,—Chief ran up and spoke: "No engine stop,—the flywheel broke,—and went clean through poor Danny's groin." Kind readers, I would like to draw a curtain over details raw. It doesn't take much time at guessing to know what happened at this plant. So let's skip funeral dirge and chant and scenes that only are distressing. Just realize that things *must* end for *you* as they did for our friend, unless—you stop your steady crying: "Oh! now conditions are so bad I need to throttle every scad," and facing 'round, *start in to buying.* Each bang-up boiler room appliance upon which you can place reliance, when needed, should be in your yard. Not several thousand miles from there because you thought you didn't dare to spend the dough cause "Times are hard."



Remodeling Switchgears for Power Systems---III

How Conditions Exist in a Rapidly Growing Plant; Current-Limiting Reactors. By Stephen Q. Hays*

AS AN EXAMPLE of a rapidly growing plant, one may be cited that was started in 1912 with two 200-kv.a. gas-engine driven units. A third unit of the same size was installed in 1913. The switching equipment for these units was furnished in 1914 and consisted of oil circuit breakers with rupturing capacity entirely adequate for a 600-kv.a. plant; but the switching equipment had to be completely remodeled in 1916, due to the furnishing of a 1250-kv.a. turbo generator in 1915, and the addition of a 3125-kv.a. turbo in 1916. During the remodeling of the switchboard, distant mechanical control oil circuit breakers were furnished for the various feeders, these being of a type with independent tanks for each pole, and were located on pipe frame in a special switchboard room. A second 3125-kv.a. turbo was installed in 1917 or 1918, and the rupturing capacity of the oil breakers was practically reached at that time. A 7800-kv.a. turbo is now being built and a second unit of the same size is contemplated, so that the entire switching equipment will have to be remodeled.

The present equipment at the generating station, as shown in Fig. 21, includes three old gas engine units with switchboards that are to be removed at an early date; one 1250-kv.a., two 3125-kv.a., 2400-v. 2-phase, 60-cycle turbo generators; one 7800-kv.a. turbo generator now being built, and probably a duplicate future unit.

The breaker structure is located in the switchboard room 24 ft. long, 12 ft. wide, 19 ft. high, having a 6-ft. basement. The feeder breakers are four-pole with individual tanks per pole, all four poles being operated together by a cross arm mechanism. The generator breakers are four-pole with all poles in the same tanks.

The switchboard room is at the left-hand end of the present generating station looking from the boiler room. The gas engine units are at the extreme right-hand end and the turbines between the location of these units and the present switchboard.

It is intended to locate the 7800-kv.a. machine at the left of the present position of the switch house. The gas engine units will be removed as soon as possible and the space formerly occupied by them at the right-hand end of the building utilized for a new switch room, clearing out the present switch room to provide a location for a future 7800-kv.a. unit.

From preliminary calculations with one additional 7800-kv.a. unit that is now being built, the present breakers will be satisfactory if provided with time limit relays and set for approximately 2 sec., but would be beyond their rating for more nearly instantaneous service. The revision of the switching layout is based on employing the present breakers furnished with time limit relays. If an additional 7800-kv.a. unit is installed, the breakers will then be beyond their capacity and a group system of switching will be needed.

With the present equipment and a single set of busses, it is impossible to inspect or repair any breaker without shutting down an important feeder circuit. The new equipment therefore contemplates a feeder breaker arrangement that will locate the breakers in pairs so that any breaker can carry the load of its own circuit as well as that of its companion. Any of the present breakers, in the feeder circuit, may then be shut down without entailing the shut-down of the feeder.

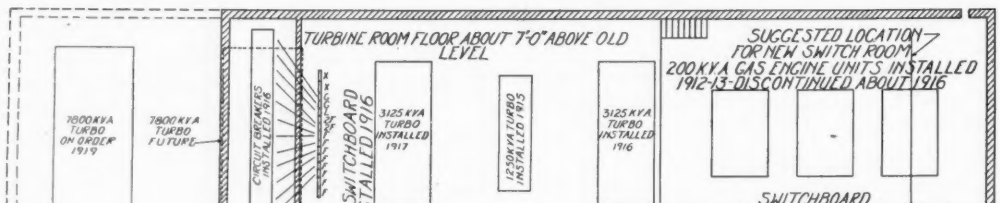

7800 KVA TURBO ON ORDER 1919
7800 KVA TURBO FUTURE
CIRCUIT BREAKERS INSTALLED 1916
TURBINE ROOM FLOOR ABOUT 7'-0" ABOVE OLD LEVEL
SWITCHBOARD INSTALLED 1916
3125 KVA TURBO INSTALLED 1917
1250 KVA TURBO INSTALLED 1915
3125 KVA TURBO INSTALLED 1916
SUGGESTED LOCATION FOR NEW SWITCH ROOM
200 KVA GAS ENGINE UNITS INSTALLED 1912-13-DISCONTINUED ABOUT 1916
SWITCHBOARD SUPPLIED 1912-13-DISMANTLED 1916
BOILER ROOM
ROTARY CONVERTERS

FIG. 21. PLAN VIEW OF GENERATING STATION

*Switchboard Expert, Westinghouse Electric and Manufacturing Co.

As the competing lighting company is arranging to change over from two-phase to three-phase equipment, it is quite possible that the apparatus of this plant may, at a later date, have to be changed in a similar manner.

As shown on Fig. 21, plan view of present station, the original equipment furnished in 1912 controlled two 200-kv.a. 2400-v. two phase, 60-cycle gas-engine units, and a third unit of the same size was installed in 1913.

For the control of these units, a switchboard was supplied in 1912 and 1913. This switchboard was dismantled in 1916, some of the panels and materials being used for the remodeled board that was then installed at the left-hand end of the building with the breakers and busses in a separate room.

In 1915, there was installed a 1250-kv.a. turbo generator with a switchboard panel, using remote control four-pole breaker. In 1916, there was installed a 3125-kv.a. turbo generator with a switchboard panel furnished this machine, being controlled by means of a four-pole breaker, distant mechanical control. In 1916, a feeder panel with remote control four-pole breaker was furnished. These panels with additional panels formed the present 15-panel switchboard.

In the actual installation of this switching equipment, the panels were erected in the reverse order from the arrangement shown on manufacturers' drawings; that is, the exciter and generator panels were located at the right-hand end looking at the front of the board.

The operating mechanism for the distant mechanical control oil circuit breakers is run with the bell cranks above the floor. In place of individual vertical rods operated by a shaft for the four independent poles of the feeder breakers, the four mechanisms of the four-pole breakers were tied together mechanically by a cross bar operated from a single vertical rod.

All of the feeder circuits were provided with four-pole breakers having independent tanks per pole, these breakers having a guaranteed rupturing capacity of 10,400 amp. at 2500 v. and being provided with current transformer trip coils, and were arranged to trip automatically in approximately 0.08 sec. The combined output of the one 1250-kv.a. generator and the two 3125-kv.a. generators is approximately 1620 amp. and these machines assumed to be approximately 12 per cent reactance would give eight times full load current in case of short circuit at the end of ¼ sec., three times full load current at the end of 2 sec.

The furnishing of the new 7800-kv.a. generator and a generator of probably similar size to be ordered in the future, would bring the normal full-load current with all units in the station running to approximately 5000 amp. Assuming all units to be of 12 per cent reactance, the momentary short-circuit current at the end of 0.08 sec. when breakers with current transformer trip would operate, would be approximately 40,000 amp.; at the end of ¼ sec. when breakers provided with overload relays set for minimum time would operate, would be approximately 22,500 amp., while the continuous short-circuit current or the current after 2 sec. would be in the neighborhood of 15,000 amp.

As the continuous short-circuit current of 15,000 amp. such as could be delivered by the contemplated plant is in excess of the rupturing capacity guaranteed on the present feeder breakers, it is proposed to install a group system arranged as shown on single line diagram Fig. 22.

As shown on that diagram, the present 1250 kv.a. generator with two present 3125 kv.a. generators and 7800 kv.a. generator now being installed will connect through suitable non-automatic breakers to either or both of two sets of 2400-v. two-phase busses, and the future generator will connect to the same busses, the generator breakers being marked on the diagram as well as on the plan view of the switching gallery as breakers A-1 to A-10 inclusive.

Breakers 1 to 9 inclusive are the present four-pole and two-pole mechanically operated breakers with their current transformer trip coils in the breaker faceplate replaced by direct-current trip coils and each circuit provided with adjustable definite minimum inverse time limit overload relays that will normally be set for a 2-sec. time limit.

Feeder breakers F-1 to F-4 inclusive are connected to group bus 1, this being fed from the main busses

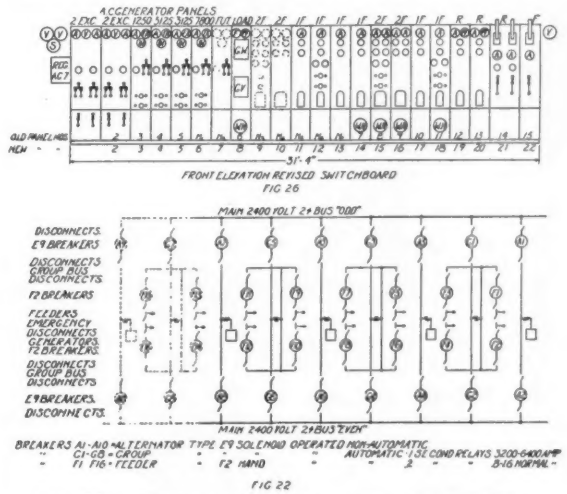


FIG. 22. SINGLE LINE DIAGRAM OF CONNECTIONS
FIG. 26. FRONT VIEW OF SWITCHBOARD

through group breaker 1 or group breaker 2. In a similar manner, feeder breakers F-5 to F-8 inclusive are fed from group bus 2 supplied through group breakers 3 and 4, and feeder circuits F-9 to F-12 inclusive are fed from group bus 3 fed through group breakers 5 and 6.

The group breakers will be 1600-amp. breakers provided with 2000 to 2½ (4000/5)-amp. current transformers and definite minimum inverse time limit relays that will normally be set for practically instantaneous service. These group breakers can be set to trip practically instantaneously on any current between the limits of 3200 to 6400 amp. Any normal overload or moderate short circuit occurring on a feeder circuit will be tripped by its individual breaker at the expiration of approximately 2 sec. unless the current flowing is of sufficient magnitude to endanger the satisfactory operation of the small breaker, in which case the group breaker will trip out at the expiration of ¼ sec. when the combined load on the ultimate plant will be in the neighborhood of 22,500 amp. The breakers for the group circuits and for the generator circuits have a guaranteed rupturing capacity of at least 30,000 amp. at 2500 v.

Figure 23 shows a section through the switch room and indicates the relative location of the large breakers on the upper gallery and the small breakers on the main switching gallery which should be on approximately the same level as the turbine room floor. Group and generator breakers will be mounted on pipe framework, the tanks being placed at such a height that they may be dropped without interfering with the solenoid operating mechanism located directly below one of the tanks. The individual poles of these breakers will be placed approximately 12 in. on centers so that the four pole breakers will be located 4 ft. on centers. Transite barriers may be placed between the four pole breakers or the individual poles as shown.

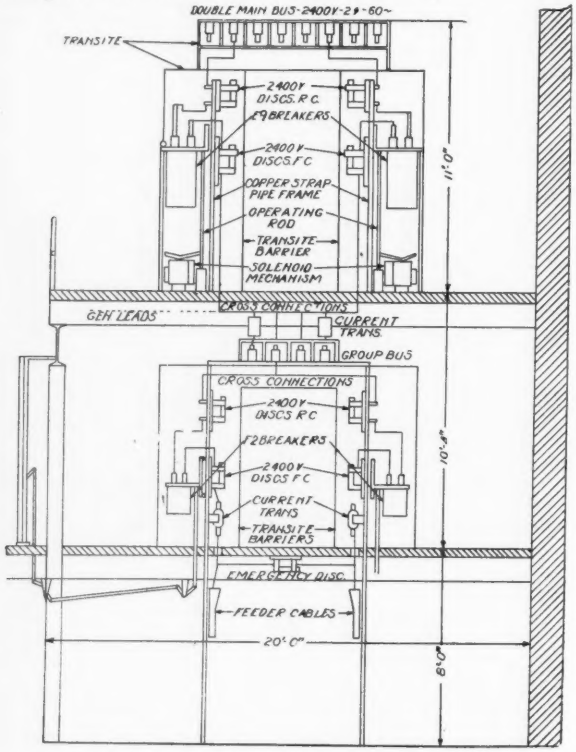


FIG. 23. SECTION THROUGH SWITCH ROOM

The double set of main 2400-v. two-phase, 60-cycle busses will be placed horizontally above the breaker structures and supported either from the roof of the station or from an extension to the pipe framework carrying the breakers. These busses have been placed within transite compartments.

The rear connected 2400-v. disconnecting switches are provided for isolating the large breakers in the main busses and front connected 2400-v. disconnecting switches are provided for cutting off the breakers from their common cross connections to which are attached either the incoming generator leads or the leads furnishing energy to the feeder group busses. On the main floor will be located the panel switchboard and the mechanically operated four-pole breakers.

In Fig. 25 showing the plan view of the main floor switch room the approximate paths of the operating rods running from the breaker handles on the switchboard panels to the breakers have been indicated by dotted lines. The actual paths may be slightly modified to dodge any beams, supports or wiring.

The small breakers have been shown as located on pipe framework and the material used for the present structure can be utilized in making all of the framework required for the new structure containing the breakers in the feeder circuits.

The present nine feeders with three additional feeders proposed to equip now, will be divided into three groups of four circuits each and provision is made for four additional feeder circuits, these feeder breakers being marked on the single line diagram and the plan view of the main floor of the switch room as breakers "F-1" to "F-16" inclusive.

Group busses will be supported on cross braces between the upright pipes of the framework and for these group busses as well as the connections from the breakers to these group busses, the present material can be utilized. Between the group busses and the feeder breakers 2400-v. rear connected disconnecting switches have been shown, these being at present installed for use with the nine feeder circuits.

On the line side of these feeder breakers 2400-v. front connected disconnecting switches have been shown, these being new for the old circuits as well as for the new circuits.

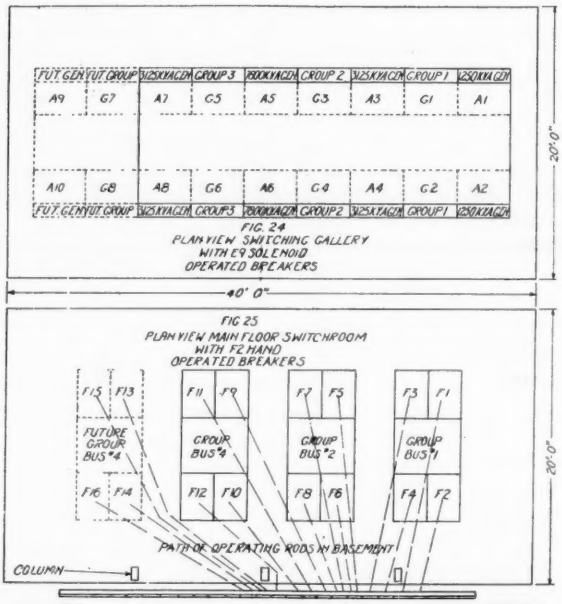


FIG. 24
PLAN VIEW SWITCHING GALLERY WITH E9 SOLENOID OPERATED BREAKERS

FIG 25
PLAN VIEW MAIN FLOOR SWITCHROOM WITH F2 HAND OPERATED BREAKERS

FIG. 24. PLAN VIEW GALLERY WITH GROUP BREAKERS
FIG. 25. PLAN VIEW GALLERY WITH FEEDER BREAKERS

Directly below the floor in the circuits cross connecting two feeders, have been shown emergency disconnecting switches so arranged that if it is necessary to keep feeder 2 in operation but to inspect feeder breaker 2 the disconnecting switches on each side of feeder breaker 2 may be pulled and feeder 2 fed through the emergency disconnecting switches and breaker "F-1" would then be furnishing the energy to feeder 1 and feeder 2.

With this arrangement, any breaker may be cut out of service without shutting down a generator or feeder circuit.

Figure 24 shows the plan view of the upper switching gallery containing the group generator breakers with the two sets of busses above them and Fig. 25 the corresponding plan view of the feeder breaker room with group busses for each four feeders.

The numbers below the panels running from 1 to 22 inclusive give the order of the panels reading from left to right for the complete switchboard. The numbers on the lower slabs of the panels from 1 to 15 inclusive are the numbers of the panels as at present. The panels marked N-1 to N-7 inclusive are new panels.

Current Limiting Reactors

Another means of taking care of a number of small feeder circuits whose breakers do not have sufficient rupturing capacity for an enlarged plant is to use current limiting reactors to hold the current down to a limit within the capacity of the breakers. Where individual feeder reactors are used, the small breakers with reactors usually cost more than new breakers of sufficient rupturing capacity to handle the conditions, so from the viewpoint of cost, the reactors are not warranted. Their other qualifications, however, such as the limiting of trouble to the feeder affected, the maintenance of bus voltage, etc., may well warrant their adoption. Group reactors, however, may sometimes show a cost saving over that of furnishing new breakers of larger rupturing capacity and these group reactors, while causing the voltage to drop on all of the feeders of that group at the same time does not have the effect of cutting off all of the feeders in the group as is done with the system of automatic group breakers described above.

In large systems, current-limiting reactors have been installed for the purpose of limiting the amount of current that may flow from any part of the system into a short circuit in the apparatus or the connections inside the station or close to the station. By so limiting the abnormal flow of current into a short circuit, the generating system as a whole is relieved from the possible disastrous effects of short circuit. At the time of the disturbance on the system, the extra load thrown on the generators by the energy fed into the short circuit is such that the generating frequency and voltage are momentarily lowered and the reactors will tend to reduce this extra load on the system and minimize the change in frequency that often throws out of step the synchronous apparatus in the substations and the generators at other connected stations.

With reduction in feeder short circuit current, the relay system can be made far more selective, the voltage in the system will not be materially affected, the energy fed into the short circuit will not tend to slow the generators down, producing a change in the system frequency, and synchronous apparatus on other parts of the system will not fall out of step. The protected feeder or group will be automatically disconnected from the system without interruption of service to the remainder of the system.

Current limiting reactors are built either as single phase or as three phase units. A typical single-phase unit is shown in Fig. 27, this having a rating of 100 kv.a., 100 amp, 25 cycles or 8 per cent on the basis of a normal three-phase circuit, at 2200 v. with one coil per phase. As these current-limiting reactors are air cooled, a comparatively large area of conductor surface must be provided to dissipate the I^2R loss and since the area of a conductor such as a cable increases with the square of the diameter, and the surface as the first power, it is obvious that the smaller the diameter of the cable, the more efficiently is the copper worked. The copper represents the large part of the cost of a reactor, hence the necessity to keep its amount to a minimum. This reasoning has led to the use of a fairly small size of cable and the use of a number of these in parallel to get the proper current carrying capacity.

With a number of cables in multiple in a coil of this kind, there is a tendency for these parallel circuits to have different ohmic and inductive characteristics unless special precautions are taken to see that the lengths and relative positions of the cables in the parallel paths are practically identical.

With a typical single-phase coil for use with a three-phase generator of 21,100 kv.a. capacity, the normal full load current was 1100 amp. and the coils were found with seven stranded bare copper cables connected in parallel in such a manner that the paths are of substantially the same lengths and impedance. The seven cables are wound into grooves in specially prepared moulded fireproof cleats. These seven cables enter the coils at seven equidistant points around the inner periphery of the bottom layer of the coil. The first cable occupies the inner circumferencial row of slots for one-seventh of a

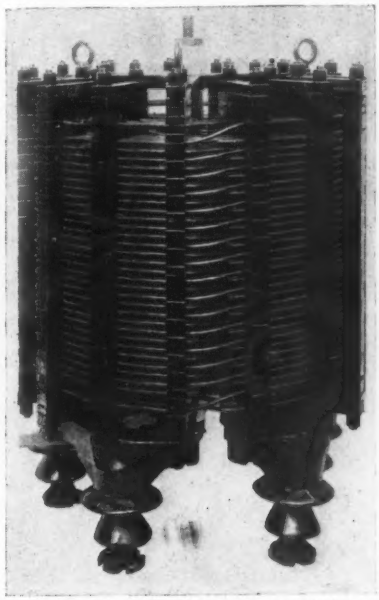


FIG. 27. SINGLE-PHASE CURRENT-LIMITING REACTOR

turn and then passes out to the second row of slots and the second cable occupies the inner row. These two continue in this position for the second seventh turn at the end of which they step outward one more row and the third cable enters on the inner row.

The moulded cleats with slots into which the cable is wound have holes in their ends through which brass rods covered by insulating tubes are placed for clamping the layers together securely. On the top and bottom of each tier of cleats is placed a non-magnetic metal cleat that allows the coil to be clamped rigidly together. The spacing between columns of cleats is close enough to prevent any appreciable deflection of the cable under the most severe short-circuit conditions. The tensile strength of the copper in the cable is sufficient to resist the magnetic stress tending to increase the diameter of the coil.

The coil is supported on three non-magnetic castings, each of which spans four tiers of cleats. Into these castings are cemented insulators which rest on metal pins

suitable for cementing or bolting to the floor. Two brass rods pass through the opening of the coil and are supported by porcelain bushings held in place by a three-way support and on each end of the rod is provided a line terminal. All of the cables at one end of the coil are connected to one rod while the cables at the other end connect to the second rod.

For three-phase feeder or group circuits of moderate capacity, a three-phase reactor such as shown in Fig. 28, can be supplied. This shows a 440-amp. 127-v. 167-kv.a. 25-cycle, 3-phase coil for use on a 6600-v. circuit. Such a coil gets the advantage of the mutual reactance between phases and it may be noted that the coils at the top and bottom are part of the same coil in one phase, while the two wider coils in the middle are for the remaining phases. Such a three-phase coil can be installed in a much smaller space than three single-phase independent coils and the wiring of the plant can frequently be simplified by their use.

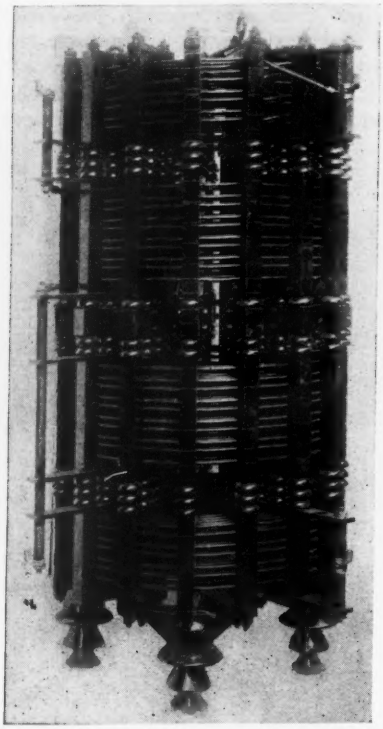


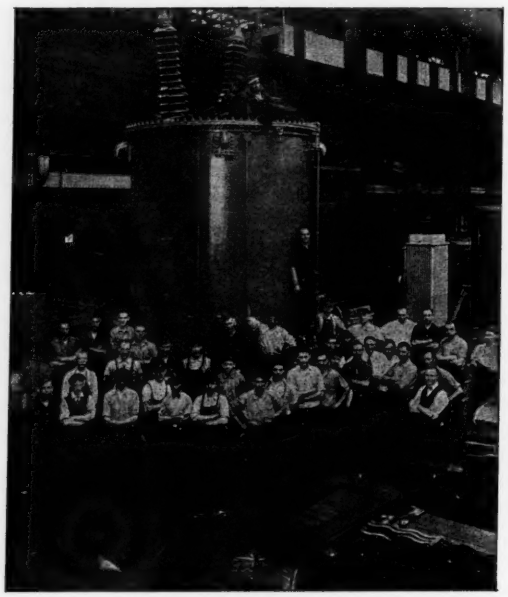
FIG. 28. THREE-PHASE CURRENT-LIMITING REACTOR

The World's Largest Transformers

THE FOUR largest transformers in the world, each of which has a capacity of 23,600 kv.a. or 35 per cent greater than any single-phase transformer heretofore constructed, were recently shipped to the Cheswick Station of the Duquesne Light Co.

The transformers at this station will be arranged in one bank of three with one spare for use on occasions of necessity. The transformers will step up the output of a three-element 70,000-kv.a. steam turbine, from the generating voltage of 11,500 to a transmission voltage of 66,000. Provision is made so that when this generating station reaches its ultimate capacity the transmission voltage may be increased to 132,000 v. This will be necessary owing to the tremendous amount of energy which will be generated at the station.

Each of the transformer tanks has a diameter of nearly 10 ft. and is approximately 16 ft. high. With the bushing in place, the total height is over 22 ft., measured from the wheels of the truck upon which the tank stands to the tip of the bushings. Each of the transformers weigh 63 tons when filled with oil, something over 18 tons of special high-grade oil being required for each transformer.



ONE OF THE LARGE TRANSFORMERS FOR THE CHESWICK STATION

Modern Ship Propulsion Methods

By W. H. Easton

NOBODY competent to pass judgment on the subject has any doubts as to the success of electrical propulsion of merchant ships from an engineering standpoint. It is merely an adaptation of thoroughly known elements to a novel service, and though plenty of "grief" can be expected before all of the mechanical and electrical factors are finally adjusted to the new conditions, the driving of a merchant ship by a motor is essentially no more difficult a problem than the driving of any other kind of a machine.

There is likewise a general consensus of opinion as to the more important advantages that will result from the use of electric propulsion. Among these are:

1. More freedom in the design of ships, because a wide range of choice is possible as to the location and arrangement of the main steam machinery.

2. A high degree of reliability, owing to the inherent simplicity of electrical apparatus.

3. Advantage in maneuvering because of the fact that full power is available for astern operation.

4. High operating efficiency as compared with the reciprocating engine, because of the use of the efficient

high-speed turbine, high vacua, superheat, and other features of modern steam practice.

5. Excellent steam turbine operating conditions, since the turbine is not reversed.

On the other hand, many engineers believe that there are two limitations to electric propulsion, namely:

1. It is not as efficient as the geared-turbine drive. About the best obtainable efficiency for a large generator or motor is 94 per cent. Therefore, for every 1000 hp. delivered by the turbine, its generator would deliver 940 hp. of electric energy to the motor, and the motor would in turn deliver 884 hp. to the propeller, so that the total loss would be about 12 per cent. The geared turbine, however, can deliver to the propeller at least 95 per cent of the power generated by the turbine.

2. Electric drive for ships requiring more than about 3000 hp. involves the use of high-voltage alternating current, because it is impractical to transmit such large powers at the ordinary "low" voltages of 550 v. or less. Inasmuch as the number of men competent to handle a high-voltage alternating-current apparatus is limited at present, it might prove difficult to pick up engine-room crews at the great majority of ports. This objection can, of course, be eliminated in time, but it evidently would prevent an immediate change-over of our entire merchant marine to electric propulsion.

Assuming that these advantages and objections are proved valid by the electrically-propelled ships now under construction, and that no other favorable or unfavorable factor develops, the following conclusions seem warranted.

For ships of great power where the efficiency of the vessel is of foremost importance, and where high-grade crews can be trained, held, and controlled by effective discipline, electric drive is especially suitable. These conditions apply to capital naval vessels and to large passenger liners.

But for the ordinary slow-speed tramp merchant vessel, which makes long voyages at its best speed, rarely changes speed or reverses, and may spend months or years away from the ports of the most highly advanced nations, it seems probable that the geared turbine will be preferred, because it is much simpler to operate; it involves no fundamental principles that are unknown to the well-informed steam engineer; and its efficiency is better than that of the electric drive.

So far reference has been confined to the "steam-electric" drive, which consists essentially of a steam turbine which operates a generator which supplies high-voltage alternating-current to the propeller motors. But a second, and quite different, electric drive is being developed, which is known as the "Diesel-electric" and consists of a Diesel engine which drives a generator which supplies low-voltage direct-current to the propeller motors.

The special advantages of this system are, that its fuel economy is high; its Diesel engine operates continuously in one direction without change of speed; and it substitutes the comparatively simple and familiar low-voltage direct-current electric system for the high-voltage alternating-current. Furthermore, the power needed to propel the ship can be divided among three or more small units instead of being concentrated in one large one. Thus in a 3000-hp. ship, there can be with Diesel-electric drive three 1000-hp. or six 500-hp. generating sets, all of which can supply power to the propeller motor, whereas with the direct Diesel drive there must be a 3000-hp. engine for a single-screw ship or two 1500-hp. engines for a twin-screw ship. Any, or in fact, almost all of the small Diesel-electric sets can be out of commission for inspection or repairs without crippling the ship, whereas trouble of any kind with the large direct-connected units may prove serious and difficult to remedy. This sub-division of units makes Diesel-electric drive exceedingly reliable and at the same time, owing to the characteristics of the oil engine, does not decrease the efficiency. The chief limitation of this drive is that its maximum power limit is about 4000 hp., so that it is essentially a system for small vessels.

Within its limits, however, it shares the chief advantages of both the Diesel engine and the steam-electric drive and also is free from some of the advantages of both, and inasmuch as the two or three small vessels equipped with it have proven highly successful, it seems destined for a wide use, especially for vessels requiring a high degree of maneuvering power such as ferry boats, fire-boats, tugs, etc.

Hence at this time it seems probable that the steam-electric drive will find its most suitable application in ships of above about 20,000 hp. capacity; that the Diesel-electric drive will be extensively used for ships of less than 3000 hp.; while the geared-turbine will dominate the field in between. But no one familiar with the course of electrical development will dare to prophesy that electric drive will never supersede all other methods of propulsion. Electricity has done many surprising things in the past and can be counted on to do more in the future, and it is quite possible that electric drive will eventually prove to have so many special advantages that it will in time become as supreme for ship propulsion as it is today for illumination.

Supporting Conduit Risers

By L. O. Rollins

THE SCHEME shown in the accompanying illustrations has proven to be very satisfactory and economical for holding the wires in a vertical conduit run so as to satisfy National Electrical Code requirements. To apply this method, the back of the junction box must be of steel sufficiently heavy that it will safely "take" a machine-screw thread, M, Fig. 1. Then the conductors can be gripped in porcelain cleats, A, B, C and D. A piece of flat strap iron with a hole in each end is placed between the outer cleat and the machine screw head. This distributes the strain and thereby prevents cracking of the porcelain. To support the conduits themselves, their ends should be threaded for some distance, as shown at L (Fig. 1) and a locknut run down on them. In fact, in some cities, the inspection bureau requires two locknuts on every conduit which enters a steel box. In such cities, a bushing and a locknut on the conduit, N, Fig. 1, are deemed insufficient. To economize space within the anchor box, it is often desirable to stagger the cleats as exhibited at C and D. A heavy angle, S, should be provided to support the vertical weight of the box and the conductors in conduit which it supports. Angle S_1 is also

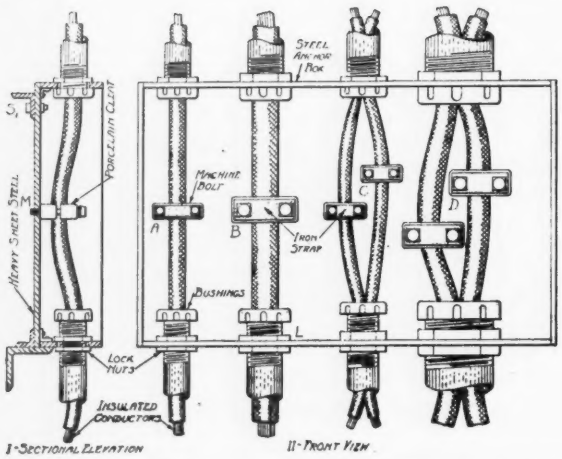


FIG. 1. SUPPORTS FOR CONDUCTORS IN VERTICAL CONDUIT RUNS

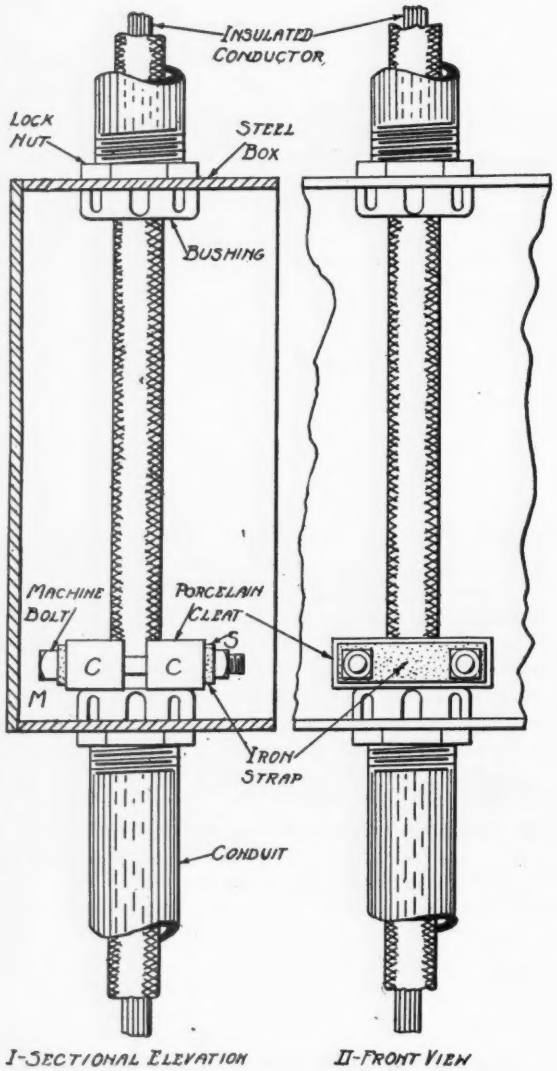


FIG. 2. CONDUCTOR IN A VERTICAL CONDUIT RUN SUPPORTED WITH A PORCELAIN CLEAT CLAMP

usually located at the top of the box and the box is bolted to it.

The arrangement given in Fig. 2 has also been applied successfully and is quite satisfactory for the smaller conductors. With this, a cleat is bolted tightly around the conductor. This cleat rests on the bushing in the bottom of the box, thus preventing the conductor from moving vertically downward.

Recent Power Station Equipment Costs

IN VIEW of the interest of engineers in equipment costs at present, the following segregated data are published for several Massachusetts central stations filing construction-cost information with the Department of public Utilities in connection with petitions for authority to issue securities. Only such data as are of general significance are presented, but virtually all these costs are 1919-1920 figures.—Electrical World.

One 12,500-kv.a. turbo-generator, erected	$195,397
One 22,000-sq. ft. surface-condensing equipment with exhaust distance piece	69,840
One 4300-kv.a., 25-cycle, three-phase, 11,000-v. generator, erected	60,200
Two 755-hp. water-tube boilers	36,886
Two 755-hp. Foster superheaters, erected	7,350
Two seven-unit Diamond soot-blowing equipments	1,544
Two seven-retort underfeed stokers with steam-power dump	11,666
Four 36-in. cast-iron ash gates	1,303
One air washer, 40,000 cu. ft. per minute	2,328
One 2000-lb. electric weighing larry	2,100
One 30-in. hydraulically operated atmospheric relief valve	1,125
One No. 8 green forced-draft fan	6,800
One 50-ton, four-motor electric crane	16,410
Two superheaters for 500-hp. boilers	8,223
Two 1500-bbl. steel fuel-oil tanks with foundation	16,738
Oil-burning equipment for 15,000-kv.a. station	90,379
One 150-kw. combination turbo-motor exciter set	9,375
One 20-ton, eight-wheel locomotive crane with 60-ft. boom	15,985
Two 1200-amp. and 14 600-amp., 15,000-v. solenoid-operated oil circuit breakers	19,725
Three 1250-kv.a. transformers, 66,000/13,000 v. water-cooled type	16,200
Three 1500-kv.a., 66,000/13,200/2200-v. water-cooled transformers	19,600
Water-cooling system for three 1500-kv.a.,66,000/13,200/2200-v. transformers	1,704
Three 2500-kv.a. transformers, 23,000-4000-v., installed, including switching and connections	20,533
Six 1000-kv.a. transformers, 13,200/2300-v., single-phase, 60-cycle, oil-insulated, self-cooled, outdoor type for bus-tie work	13,388
Four 100-kv.a., 2300/230/115-v. oil-insulated, self-cooled transformers, indoor type, auxiliary station service, single-phase, 60-cycle	2,222
One 1300-amp., 6-ohm, 15,000-v., 350-deg. C. (1 min.) neutral-grounding resister for 12,500-kv.a. generator	2,600
Two 13,200-v., three-phase, 60-cycle oxide-film lightning arresters, with fuses, etc., for 13,200-v. bus	1,122
One 46-kv.a., 200-amp., 2200-v., 60-cycle feeder-voltage regulator, complete with three-phase non-automatic motor control, f.o.b. factory	1,272
Five 66,000-v. potential transformers	9,540
One 66,000-v. air-break switch	970
Four 200-amp. and five 300-amp. feeder reactors	8,108

ONLY a watch repairer can keep his eyes on the timepiece and still tend to business.

What Is the Matter with Belt Theory?

By W. F. Schaphorst*

THE success of the slack belt has had the tendency, of late, to put a sort of "crimp" in the theory of tight belts. Belt theorists and mathematicians have been unable to explain just why the slack belt works so well and they are therefore disposed to call them "freak drivers."

Let's see now. Are they freak drivers? Here is a typical example. John Smith has a large belt connecting an engine and generator which *should* transmit 100 hp., but it slips badly and he tightens it until it doesn't slip. The belt stretches quickly and slips again, and again John Smith tightens it. If he believes in Taylor's belt methods, he will look into a book and find a table that tells exactly how tightly the belt should be stretched. He follows the rules to the last letter, but in vain. The drive continues to give him trouble.

In comes a salesman for a belt treatment concern who takes in the situation at a glance and starts preaching "slack belt" to John Smith. John throws up his hands in the usual holy horror fashion and gasps, "It can't be done." The salesman says it *can* be done, however, and he is so positive and enthusiastic about it that John finally agrees to give the salesman his way; and the belt receives its first treatment forthwith.

About a month later, that belt of John Smith's is as nice and pretty and slack as any other slack belt. It has stopped slipping. John wears a smile instead of a careworn expression. His days of continual retightening are over. He is satisfied even though theorists might now call his drive a "freak drive." It does the work with utmost satisfaction, and that is as much as anybody could ever want.

Now the above is *not* a mere "happenstance," as one would be liable to think who is versed only in tight belts. It is an every-day occurrence for the slack-belt man. He can't always make a belt run so slack that the sides touch, but he can at least reduce the tension enough to relieve the bearings of much of their load, and the belt will pull full load with apparent ease.

How is it possible for this man to go around day after day and persistently "knock the whey out of our text-book belt theory"? Must we conclude that something is wrong with our belting theory?

Personally, I have delved into the theory end of the problem to some extent and find it O. K. for dry untreated belts, but for treated belts Taylor's ideas were not far enough advanced. I guess he never saw a nice slack belt or he wouldn't have written what he wrote.

We will now proceed into one of the foregoing "typical examples" which later developed into and is now often called a "freak drive."

In the sketch B shows the drive before it was made slack as shown in A. My drawing is exactly to scale. The driving pulley is 30 in. in diameter; the driven pulley 28 in. in diameter; the distance between shaft centers is 14 ft.; the speed of the belt is 5300 ft. per min.; it is made of two-ply leather; is 12 in. wide; and today transmits 70 hp. without slipping even though the belt is running 24½ in. slack.

*All rights reserved by the author.

Well, when the salesman first found this belt, it was running so tight that it seemed to hurt. There was hardly a sag in the "slack" side at all even when pulling full load. And what was worse, it didn't pull the load the way it should; it slipped "to beat the band," as the engineer on the job said. The salesman measured the sag as well as he could and found it to be 2 in.

All right. Now what is the tension in a belt 14 ft. long sagging 2 in.?

Here is the formula for leather belts:

(1) $(0.43\ D^2 \div 8\ S) + 0.43\ S =$ tension lb. per sq. in.

Where D = length of belt between supports in feet;
S = sag of belt in feet.

Substitute our known values in this formula and you will get 63.3 lb. per sq. in. for an answer.

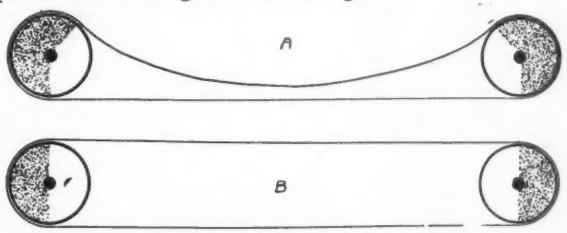
Since a two-ply belt is about ⅜ in. thick, the cross-sectional area of this one is about

$$12 \times \tfrac{3}{8} = 4\tfrac{1}{2} \text{ sq. in.}$$

The total tension in the belt was therefore

$$63.3 \times 4\tfrac{1}{2} = 285 \text{ lb.}$$

Very good. We are now ready to compute the horsepower that this tight belt should pull.



DIAGRAMS OF SLACK AND TIGHT BELT DRIVES SHOWING ARCS OF CONTACT

The arc of contact, you will note, could hardly be more than 180 deg. We will therefore use 180 deg. in our computations. For the coefficient of friction, that isn't so easy, but as already stated the belt was slipping and since 0.30 is used a great deal for leather belts, we will use it here also.

The formula the theorists use is this:

(2) $\text{Log}\ (T_2 \div T_1) = 0.0076\ u\ O$

Where T_2 = total tension on the tight side;
T_1 = total tension on the slack side;
u = coefficient of friction;
O = the degrees of belt contact.

Substituting our known, computed and assumed values we therefore get

$$\text{Log}\ (T_2 \div 285) = 0.0076 \times 0.30 \times 180 = 0.41$$

Looking into the logarithm tables we find that 0.41 is the logarithm of 2.57, whence we get the equation,

$$T_2 \div 285 = 2.57$$

Therefore, $T_2 = 285 \times 2.57 = 733$

The pull that actually "does the business" is $T_2 - T_1$ and that, of course, is

$$733 - 285 = 448 \text{ lb.}$$

The horsepower of the belt then was

$$\frac{448 \times 5300}{33{,}000} = 72 \text{ hp.}$$

Now what do you think of that? Isn't that pretty close? Haven't I proven here that the theory of belts is O. K.?

Well, not exactly. This belt slipped, you know, and it therefore wasn't pulling 72 hp. Our conclusion must therefore be that the coefficient of friction was even less than 0.30.

Now, in comes the salesman. The sag of the belt is *increased*, and that reduces the tension T_1. If you don't believe it, look at Formula 1 for computing belt tensions. The sag is increased to 24½ in.; but at the same time, the arc of contact is considerably increased, as you may note by inspecting Sketch A. Formula 2 shows that it is advisable, always, to have as large an arc of contact as possible. The shaded arc shows that with the belt running 24½ in. slack the contact covers about 225 deg., an increase of 45 deg. over the arc shown in B with a tight belt.

Referring now to Formula 2, there is only one mysterious quantity—the unknown quantity—the coefficient of friction u. How much is it? Is it greater than 0.30 or less than 0.30? The best way is to find out, as follows:

The speed of the belt being 5300 ft. per min.; and the horsepower transmitted being 70, we get this equation where P = "effective pull."

$$P \times 5300 \div 33{,}000 = 70$$

Solving, $P = 70 \times 33{,}000 \div 5300 \times 435$ lb.

This "effective pull," as stated before, is equal to $T_2 - T_1$.

We can now easily find the value of T_1 by use of Formula 1. Here are the figures already substituted so you won't have to do it yourself:

$$\frac{0.43 \times 14 \times 14 \times 12}{8 \times 24.5} + \frac{0.43 \times 24.5}{12} = 6 \text{ lb. per sq. in.}$$

Multiplying this by the sectional area of the belt, 4½ sq. in., we find the tension on the slack side (T_1) to be 27 lb.

T_2 is therefore equal to $435 - 27 = 462$ lb.

Now, knowing both T_2 and T_1, we have

$$\text{Log } \frac{T_2}{T_1} = \text{Log } \frac{462}{27} = \text{Log } 17.1 = 1.233 = 0.0076 \text{ u d} = [0.0076 \text{ u } 225$$

Solving for u

$$u = \frac{1.233}{0.0076 \times 225} = 0.722$$

So, that's what the salesman did. The whole story is plainly told right here in common mathematics. The salesman more than doubled the coefficient of friction by carefully treating the belt, making it more pliable, permitting it to come into more intimate contact with the pulleys; and at the same time he increased the arc of contact (45 ÷ 180) 25 per cent. His process was certainly simple enough and logical enough. Formula 2 tells us pointblank that in order to make the ratio $\frac{T_2}{T_1}$ as high as possible, we must make u and O as large as possible. Instead of doing that, the ordinary tight belt theorist goes at it "left-handed." He doesn't see the right-hand side of the equation at all. He preaches, "Tension! Tension! Tension!" and lets u and O take care of themselves.

Look into our handbooks, if you please, and you won't find any belt coefficient of friction given as high as 0.72; 0.50 and 0.55 are the highest given in my handbooks.

It is a fact, though, that the coefficient of friction *increases* with the belt's velocity. Prof. Kammerer of Europe discovered that trait in belts not long ago. So, perhaps, that explains why we have so high a coefficient of friction in this example, and in all treated belt examples. That also explains why slow-running belts cannot be run slack so easily as can the high velocity belts. Most coefficients are determined in non-running tests, which is hardly fair to the running belt. The test should logically be made when the belt is running and pulling a load.

I therefore conclude that there is nothing the matter with Formula 2. The fault lies in the theorists. Formula 2 is based on sound science and mathematics, and so is Formula 1. The trouble has been that theorists have endeavored to force practice in an unnatural way. Instead of making their theory conform with natural practice, they held it aloof. Theory and practice should always work hand in hand. In fact it is impossible for them to be at variance, for if they are one or the other must be wrong. In the case of belts, I say that the tight-belt theory is wrong when it dotes too much on tension and neglects the condition of the belt and the arc of contact. Every condition must be carefully considered in justice to practice.

For example, Christopher Columbus had a theory. His theory was that the earth was round. His theory was correct. We all agree on that point now. However, he had another theory—that India could be reached by sailing west more quickly than by sailing around Africa. His second theory was wrong and we all know that too. In navigation and in many other phases of life theory and practice pull together very well. They are in perfect harmony most of the time. That is as it should be.

The day, therefore, will come, I am sure, when belt theory and practice will be in better harmony. Theory will eventually have to bend its knee to the practice of properly treated belts running slack, with bearings eased, with minimum stress per square inch in the belt itself, and with better chances for a longer and more useful life.

Basing my theory on Formula 2, I say the correct theory is—make T_1 as small as possible; make u as high as possible; and make O as large as possible. This will give you an ideal belt drive.

Electrical Advance in Denver, Colo.

FROM FIGURES compiled by Charles H. Elliott, of the Denver Gas and Electric Co., we are able to show the march of gas and electricity for the past 7 yr. and it is noticeable that electricity is in the lead.

Year	Gas	Electric	Total
1914	929	1931	2860
1915	323	1947	2270
1916	1395	2738	4133
1917	1795	2711	4506
1918	2497	2764	5261
1919	2271	3276	5547
1920	2657	3435	6092

The foregoing figures show the number of new subscribers and not the total for the city.

A Prehistoric Air Compressor

SIMPLICITY, PURE AIR, NO LUBRICATION, FEATURES OF WATER PISTON AIR COMPRESSOR. BY FRANK RICHARDS

I DO NOT feel at liberty to say how there came to me the detailed knowledge of the device here presented; and, in fact, if I so wished, I would find it difficult to put the particulars into readable shape. The only thing of which we may all be assured is that, as my title suggests, it is really and truly prehistoric, or, in other words, it antedates all history of it, and no word or print of it is to be found no matter how far back our search may be extended.

An incontrovertible and suggestive characteristic of this device, as bearing upon the antiquity of it, is its extreme simplicity. If we take the trouble to run over in our minds the progress of development of any of the world's most valued and now most indispensable contrivances we find invariably that the first idea was extremely crude and the first embodiment of it most elementary.

When it had been found that the thing, whatever it was, would actually work, and would do something like what was wanted of it, then the task of improving it began, the improvement always consisting of the adding of successive chunks of ingenuity and complication one after another. This would be likely to go on for an indefinite period until later there would come a realization of the everlasting principle that an addition is not always and necessarily an improvement, and that at the last many of these improvements may be discarded and the thing ultimately restored to its pristine simplicity; but it is only the first stage of this simplicity and not the last with which we are here concerned.

When we come to think of it the mechanical compressing of air cannot well be anything but a simple operation, and it would seem that it could only be done by simple means. The crude sketch, Fig. 1, here presented embodies every functional and essential feature of the prehistoric compressor of which we are to speak. It would seem to be entirely self-explanatory, and words of description should be superfluous. At the right is a vertical cylinder with a reciprocating piston as of an ordinary water pump, and at the left is another cylinder, without a piston of approximately equal capacity in which the actual operation of compressing the air takes place. This separate compressing cylinder at once suggests the separate condenser of James Watt, but the functions of the two are not comparable, either by contrast or otherwise.

When the water piston discards and has reached the limit of its downward stroke, which limit should be, as indicated by the dotted line, slightly below the partition between the two cylinders, then all the space below the piston, the entire compressing cylinder and all the connecting chambers at the bottom are filled entirely with water.

This may be taken as our starting point in describing the complete cycle of operation. When the piston rises in its return stroke, the water in the compressing cylinder descends and then passing to the other cylinder follows the piston in its upward stroke, while the compressing cylinder is filled with free air entering through the inlet valves. Of these valves there are here assumed to be three, only one appearing in the sketch. When the piston has reached the upper limit of its stroke the compressing cylinder is filled with air and the inlet valves automatically close. Upon the descent of the piston the water rises in the compressing cylinder and the contained air is compressed and then expelled through the discharge valves, the water being in sufficient quantity to follow up the air until all of it is driven out, leaving no unfilled clearance space. This cycle of operations is repeated with each double stroke of the piston, leaving not another word to be said in explanation of the air compressing operation.

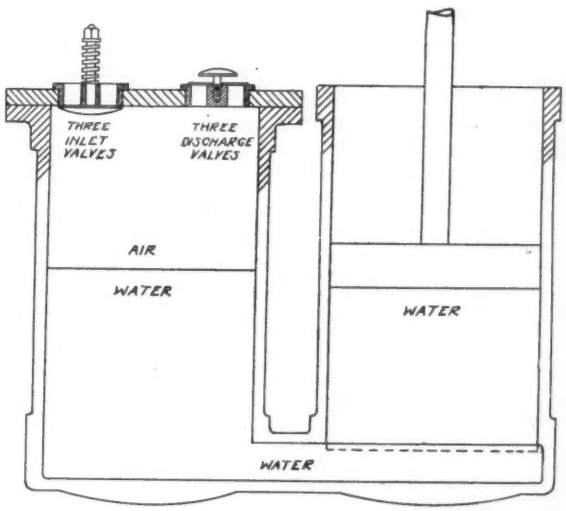


FIG. 1. ESSENTIALS OF A PREHISTORIC AIR COMPRESSOR

The sketch here presented is only intended to show the principle of operation as above described, and nothing is meant to be even hinted at of the ultimate details of design and construction for practical service. It will be sufficiently evident that the valves here shown are not "prehistoric," and it may be assumed that in any machine of sufficient size the two cylinders will not be comprised in a single casting, and that neither cylinder will be integral with the base. Any good designer will be able to settle these things according to the capacity, the working pressure and other details of the individual machine.

Now, I must contend that there is no dishonesty or untruth in my designation of this compressor, and no deception except as the reader may deceive himself. The machine as shown is really and truly prehistoric in that it precedes all history of it, and it is now for history to follow it up, as histories do, with its theories and deductions. What have we in this compressor that we have not in other compressors? It would be better to reverse the question: What do we not have in this compressor that we do have in other compressors? In the particulars which are here conspicuous by their absence are to

be found the presumptive advantages of this machine over others.

For one thing—and it is not a little thing—we do not have any lubricant about this machine. Oil or grease, or any of their substitutes or disguises, are banished entirely with all the troubles they entail, and in this alone is all the backing for the device that could be desired. There is no oil to be bought, no oil to be stored, no oil to be systematically dosed—even in homeopathic doses—to the machine, no oil to cling to and burn onto the cylinder and piston surfaces, no oil to stick to the valves and choke the passages, no oil fumes to mix with the air, no formation of explosive mixtures with the possibility of destructive explosions. There is no polluting of the air in any way, and it must leave the compressor as pure as when it enters. It may be inhaled without suggestion of complaint by the sandhogs in pneumatic caissons or in tunnel driving. It may come in contact with food products anywhere or be used in connection with the most delicate chemical manipulations.

It will be evident at once also that with this compressor in full operation there will be no unfilled clearance space remaining at the end of the compression stroke, and no air will remain undelivered after its compression, so that no deductions or allowances from its full operating volumetric capacity will be demanded.

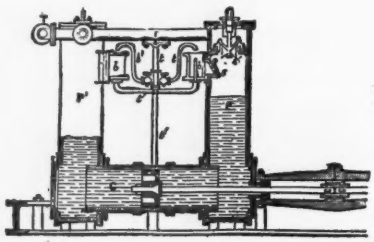


FIG. 2. DIAGRAM OF MODERN AIR COMPRESSOR WITH WATER PISTON

The water which will be driving up the air at the completion of the compression stroke will adapt itself to all irregularities of contour, all projections or depressions of surface, and a little water in excess will pass through the discharge valves and be delivered and carried along with the air. The discharge valves and seats will thus be as clean and as operatively tight as those of a water pump, and no air will have to be reckoned with as leaking back to be recompressed. The slight excess of water here spoken of will be maintained by the admission of a minute quantity of water with the intake air.

Another detail also helping to assure the complete volumetric efficiency is the temperature of the air at the beginning of the compression operation. We know that with any of the dry reciprocating compressors in use, the temperature of the air must be raised more or less—and no indicator card will tell us anything about it—in passing the heated inlet valves and ports and by contact with the heated surfaces of the cylinder, cylinder head and piston, and that the actual content of the cylinder when compression begins must be somewhat less than the apparent volume as computed from the known capacity. With our water here so omnipresent, this heating of the air cannot occur and the computed or apparent quantity of air must be very close to the reality.

The compression of the air thus in immediate contact with water all through the operation brings to our attention again the now familiar paradox that the intimate contact of the air with the water will not cause the air to be any wetter or to have more water in suspension after the completion of the compression and the cooling of the compressed air to normal temperature than if the air were compressed by any dry working machine of the familiar mechanical types.

In any case, the air will contain its full quota of water vapor up to the point of saturation, and in addition to that a surplus of actual water, probably for the time in the form of globules more or less minute, and this excess of moisture if not disposed of by some efficient separator will be carried along in the pipes and make its presence known in troublesome ways. The after-cooler and the separator, and both functions may be combined in a single apparatus, should be considered indispensable in any up-to-date compressor, and our prehistoric machine could not claim exemption.

It is not forgotten in this writing that water has been used before for the compression of air, both by direct pressure, which is necessarily extremely wasteful of power, but also as a detail of mechanically driven compressors. Figure 2 is a sketch of one of those machines which may be said to belong to the ancient history of air compression. The device shown in the present article is very different by reason of its prehistoric simplicity. While it has important practical advantages, as spoken of above, there are still objections which might be urged against it, which it is not my purpose to speak of here. The machine is certainly deserving of study as to its possibilities.

Power Company Seeking Rate Increase

By J. B. Dillon

MORE than a year ago the Colorado Power Co. sought a 40 per cent increase in rates, but the hearing has been delayed because of an order requiring the company to return an inventory of valuation. This inventory is now present and it shows a valuation of $9,819,233, based on original cost and $18,641,971, based on present cost of reproduction.

The power plant of this company is at Shoshone, Colo., about 250 mi. from Denver, and is a hydroelectric, but the current therefrom supplies the mining industries of Clear Creek, Leadville, the city of Denver and many towns in the northern part of the state.

The great opponents of the raise are the mining industries, claiming that the present depressed condition of mining will not permit of their meeting the increased cost.

Bright

CHIEF: "Say! What's the big idea? Throwing all that good coal over the bridge wall?"

Colored Fireman: "De boss man done tol' me, 'Big boy, cover dat big black spot'n youah fiah.' Dats de onlies' black spot ah could see. Gwine take a heap o' coal too."

Cutting Cast Iron with the Oxygen Blowpipe

PRACTICAL SUGGESTIONS FOR THE OPERATOR

WHILE THE oxy-acetylene blowpipe was not originally designed with a view to cutting cast iron, after exhaustive experiments, a method of operating the torch in cast-iron cutting has been developed which can be mastered by the average operator almost as easily as the method employed for the cutting of steel.

There is, however, a decided difference in respect to procedure. In practice, cast-iron cutting with the oxy-acetylene blowpipe differs from steel cutting in that:

(a) It is necessary to use heating flame having an excess of acetylene.

(b) It is necessary to hold the blowpipe nozzle farther away from the metal.

(c) It is necessary to preheat for a longer period for cast iron than for steel, since the cast iron must be almost molten before the cutting reaction will start. Steel ignites at a temperature well below its melting point.

(d) It is necessary to oscillate the nozzle continually to maintain the cut.

A cast-iron cut, if properly handled, and if the material is of good quality, will have an appearance about equal to that of a fair cut in steel.

The time required for cutting a given section of cast iron is about twice that required for cutting a similar section of steel. This makes the cost considerably higher in the instance of cast iron and tends to restrict its applications in many places where one might suppose it would be generally useful. For example, the inexpensive methods employed for removing risers from castings in iron foundries preclude the use of oxy-acetylene as an economical means of performing this class of work. Further, the cutting off of risers from chilled iron castings is usually not practical because the surfaces cut are likely to crack or check, due to local heating.

The use of cast-iron cutting is already being appreciated in the steel mills, where it was introduced more than a year ago. In those plants its demonstration was received enthusiastically, and cast-iron cutting has since been used daily in that and other industries for removing broken machinery parts such as pinions, gears, flywheels, housings, etc. The removal of such parts by old methods usually required several days because of frozen shafts, bolts and the like. With the cutting blowpipe the broken part, and sometimes parts adjacent to it, are cut quickly, the parts removed, repaired, or new parts installed, all within a few hours.

The blowpipe manipulations for cutting good grades of cast iron and for cutting poor grades of cast iron are quite different and are both described below. Although there is a difference in the manipulation of the blowpipe, the oxygen pressures used and the adjustment of the flame are the same for both grades of metal.

METHOD FOR CUTTING GOOD GRADES OF CAST IRON

ADJUST THE OXYGEN cutting regulator to give the correct pressure as shown in the cast-iron cutting table for the work to be done, having the blowpipe cutting valve open. Then close cutting valve.

(2) Open the oxygen valve one-half turn and the acetylene valve fully and light blowpipe. Open cutting valve and adjust acetylene valve to give flames having an excess of acetylene the length shown in the cutting chart. Then close cutting valve.

(3) Hold blowpipe so that the nozzle points *backward* at an angle of 45 deg., with the inner cones (not the excess cones) ⅛ in. to ¼ in. above the surface, give the nozzle a swinging motion describing semi-circles over the end of the line of cutting and heat a semi-circular area about ½ in. to ¾ in. diameter to a bright cherry.

(4) Move nozzle just off the heated edge, open cutting valve quickly and move nozzle (at 45 deg.) forward along the line of the cut with the same swinging motion.

(5) While advancing the nozzle gradually straighten it up so that it is about 75 deg. pointing *backward* when at the inner edge of the previously heated semi-circular area.

(6) Advance nozzle about ¼ in. to burn off the molten surface, then quickly move it backward to burn through the comparatively dark layer and lower section, then hold it steady for a moment to heat the upper surface. This movement can be best practiced by counting as follows: 1 forward, 2 back, 3 hold; 1 forward, 2 back, 3 hold, etc., etc.

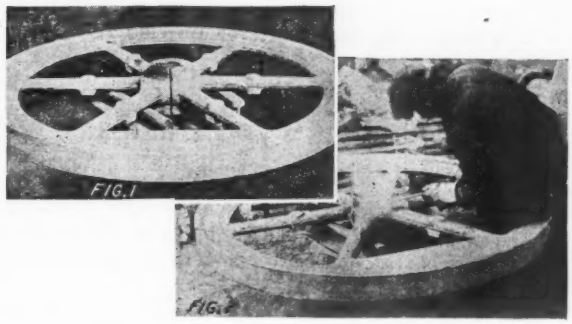


FIG. 1. FLYWHEEL SLOT CUT OUT, LEAVING CLEAN, SOUND, EASILY MACHINED METAL

FIG. 2. CUTTING SLAG AND BROKEN CORE OUT OF CAST-IRON FLYWHEEL SLOT

(7) Continue moving the nozzle in this manner at the rate of about one complete cycle per second.

(8) When the far edge is reached, carry nozzle over the edge and across the other surface, holding it at about the angle of the lag, and cut through the lag section.

METHOD FOR CUTTING POOR GRADES OF CAST IRON

FOLLOW THE directions given for cutting good grade gray iron, except that instead of using the peculiar motion explained, advance the nozzle slowly, describing semi-circles from about ¼ in. to ½ in. wide across the line of the cut, holding the blowpipe at about 75 deg. pointing backward.

NOTES ON CAST-IRON CUTTING

IN CUTTING cast iron a dark layer will be found extending down from the top surface about 1 in. to 1½ in.

Below that layer the material will be bright, having an appearance about the same as steel.

Be sure that the forward and backward, or the semi-circular movement of the nozzle allows the blowpipe to cut almost perpendicularly through the dark layer. The lag must not start until below that section. Particular attention must be paid to this condition.

If cut is lost, move nozzle back along one edge of the kerf about ½ in. and describe semi-circles lapping that edge and that point where the cut stopped. If the cut is not readily resumed, carry the semi-circles over to include both edges of the cut and the point where the cut stopped.

CAST-IRON CUTTING TABLE

Size of Nozzle	Thickness of Metal In.	Oxygen Pressure lb.sq.in.	Length of Excess Acetylene In.
No. 3....	.5	45	.... 1 to 1.5
	.75	50	
	1	55	
	1.25	60	
	1.50	65	
	1.75	70	
	2	75	
No. 4....	3	85	.... 1 to 2
	4	95	
	5	105	
	6	115	
	8	125	
	10	135	
	12	175	

Make sure of ample protection from the heat before starting so that it will not be necessary to stop the cutting operation to take shelter or provide further protection.

Pulsating Type Pumps

By Tom Thumb

THE average engineer understands quite thoroughly the action of the ordinary complex or duplex steam pump, but is not conversant with pumps of the pulsating type.

As early as 1698, Captain Thomas Savery was granted a patent in England for a device to pump water by energy developed by heating water until steam was formed, steam thus furnishing the power by which water was lifted and elevated. Figure 1 shows the device. A casting, A, with steam connection at top and water connection at bottom, formed the machine. Steam was turned on and filled the reservoir, and then shut off. The steam, upon condensing, formed a vacuum, raising water in the suction line. The next time steam was turned on, the water was forced up through discharge line. As two of these reservoirs were ordinarily used the action was quite regular but depended upon the attendant who opened the steam valves and closed them at the proper time. When the attendant was busy with the fires the pump was of necessity stopped.

After several years, along comes the pulsometer pump, Fig. 2. The action is identical with Captain Savery's machine, but is automatic. A bronze ball in the neck of the bottle, as it were, opens first one port and then the other, and water is lifted, fills the bottle and is discharged almost as regularly as a clock. That the steam entering to drive the water out shall not be condensed by contact with the water, a thin film of air is introduced through a cock designed for the purpose. Plates are so stationed that the valves at suction and discharge ports may be readily removed and replaced.

Along the same lines is the Emerson steam pump, Fig. 3. This machine also lifts and discharges water with great precision. A small inclosed "Brotherhood" engine operates the valve that admits steam to first one and then the other cylinder. Also that the condensation action shall be on time and each cylinder shall fill properly, a spray nozzle is placed in each cylinder.

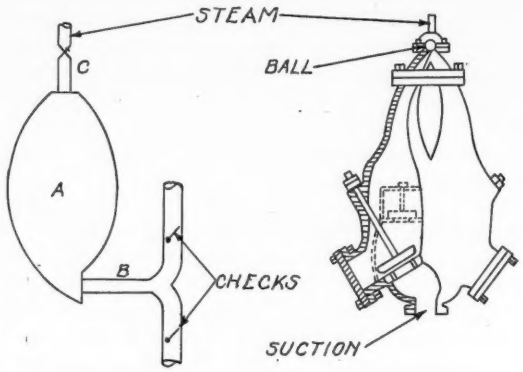


FIG. 1 FIG. 2

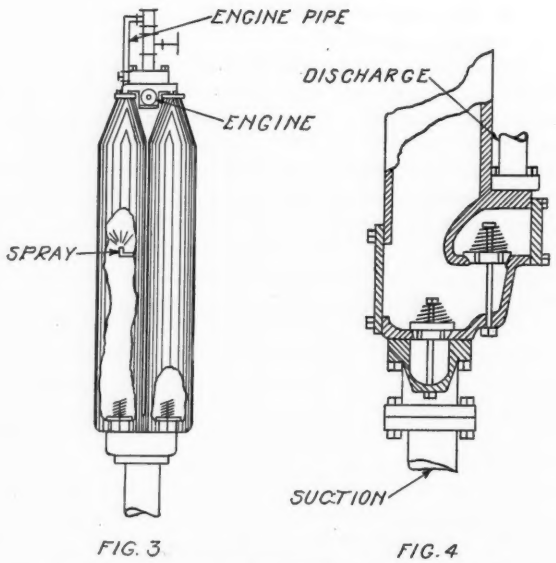


FIG. 3 FIG. 4

FIG. 1. SKETCH OF SAVERY'S PATENT PUMP
FIG. 2. PULSOMETER PUMP
FIG. 3. VALVE ASSEMBLY OF EMERSON PUMP
FIG. 4. EMERSON PUMP

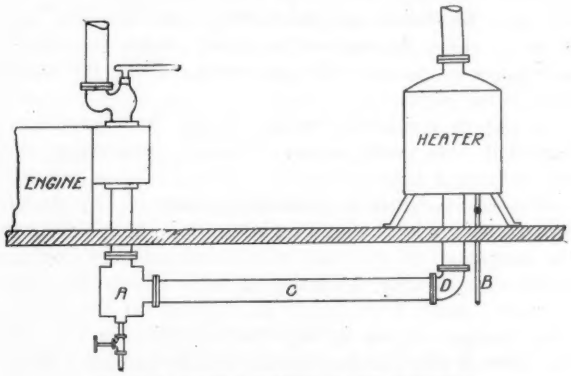
The discharge from one cylinder operates the spray in opposite cylinder automatically. This machine also has air cocks which serve to place a thin film of air between entering steam and water to be discharged. The rapidity of the action of these pumps is truly remarkable and it is no uncommon thing to pump as high as 2000 gal. per min.

Figure 4 shows the suction and discharge valve of one side of the Emerson. The engine of the Emerson pump is composed of three cylinders taking steam on both sides of pistons at the same time; it still whirls right along with never a miss and requires no attention.

Engine Wreck Narrowly Averted

A "NEAR" WRECK occurred to an engine fitted up somewhat like the plan shown. As far as known to me, the trouble was caused by the drip valve attached to the separator becoming choked up with foreign matter or thickened cylinder oil.

To reach the separator, it was necessary to raise a trap door in the floor; perhaps for this reason it was neglected. When water collected in the exhaust pipe,



ENGINE PIPING WHICH GAVE TROUBLE

the engineer was notified about the danger by the very distinctive noise such a condition will cause. He was somewhat in doubt as to what he should do; if he closed the throttle valve, a partial vacuum might be found, which would cause the water in the exhaust pipe to enter the cylinder; the momentum of the flywheel would cause the engine to turn over many times with perhaps enough power to break the cylinder head by forcing the water against it. If he left the throttle open, the same danger of water reaching the cylinder existed.

What the engineer did do was to lift the trap door and break the valve off the separator; there was no time to disconnect unions and unscrew the valve. It was a ⅜-in. globe valve. He now has a ¾-in. gate valve attached in its place.

I may state that more than once I have seen and heard about ¼ and ⅜-in. globe valves being choked with thickened cylinder oil. Gate valves only should be used on drip pipes containing cylinder oil.

JAMES E. NOBLE.

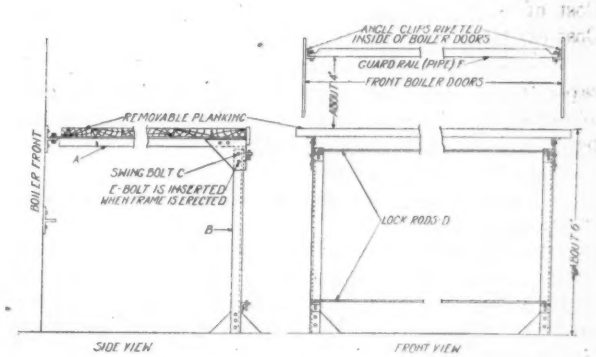
Portable Boiler Washing Platform

WHEN THE average boiler room operator thinks of a boiler washing platform, he thinks of a couple of rickety wooden horses placed in front of a boiler, over the top of which are stretched a number of wooden planks. As a rule, these horses and planks are old and in a bad order, being thrown in some corner when not in use.

In a Western plant where safety is the watchword and where every precaution is taken to guard against accident, they use a number of platforms which are made up of light angle iron as shown in the sketches.

The platform frame consists of two horizontal pieces and two vertical pieces, each horizontal and vertical piece being permanently hinged together at the joint as shown. When the platforms are not in use, each of these units can be jack-knife closed and occupies but very little space.

The method of using this platform is as follows: When a boiler is taken down, the horizontal length A



PORTABLE BOILER WASHING PLATFORM AND DETAILS

is bolted to the horizontal angle iron on the boiler front and the vertical piece B is let down into place. In a similar manner, the other section is put into place. Then the horizontal lock rods D are dropped into place, thus making the framework solid. The second bolt E is then put through the hinged joint between A and B and the planking laid on the frame.

The front boiler doors are then opened and the guard rail F is bolted into place. We now have a stable, durable, safe platform for the operators to work upon with a guard rail to keep them from falling off, which also serves to keep the doors open. The value of this rig is that it is durable, substantial, light, and takes up very little room when not in use, as all parts either fold up or can be easily taken off. In addition to the foregoing there is plenty of room underneath this platform for men to work in the firebox and pass tools and material in and out without congestion.

CLAUDE C. BROWN.

Good Load Factor

FAVORED with an exceptionally good load factor, an office building in Chicago made the showing in 1919 tabulated below.

Each 250-hp., horizontally baffled boiler has an automatic coal scale, differential draft gage and recording flue gas thermometer.

The lower baffle is open 24 in. and upper baffle, 30 in. At the end of the upper baffle, we dropped a short vertical baffle, six tubes deep, the boiler being 12 tubes deep.

Coal used, Illinois screenings, 11,500 B.t.u.; heating surface, 2500 sq. ft.; grate surface, 46.5 sq. ft.

Total coal received	10,209,450 lb.
Total coal used	10,202,800 lb.
Total coal unaccounted for	6,650 lb.
Total steam generated	73,888,000 lb.
Total steam charged	71,985,104 lb.
Total steam unaccounted for	1,902,896 lb.
Actual evaporation per pound of coal	7.24 lb.
Moisture	8 per cent
Factor of evaporation	1.06
Evaporation from and at 212 deg.	8.34 lb.
Combined boiler and furnace efficiency	70 per cent
Boiler load factor	94.5 per cent
Cost of steam generation	$43,826.50
Cost per 1000 lb. steam	0.593
Cost of coal and ash	60 per cent
Cost of labor	17.6 per cent

Average load on last watch was 54 per cent of rated capacity; average load on day watch was 145 per cent of rated capacity; maximum combustion per square foot per hour was 44 lb. for 8-hr. shift.

One boiler only in service.

On several occasions we maintained 180 per cent load for 4 hr.

One day at 9 a. m., we had a link break in the chain grate on No. 2 boiler and it tore the chain across all but three links. We held our load for 50 min. until we got another boiler cut in. Load at the time was about 140 per cent.

In electric generation, we sold 65.5 per cent of output; building used 27.3 per cent.; plant used 4.5 per cent; unaccounted for, 2.7 per cent.

JAY SEE.

Massachusetts Examination Questions for Second Class Firemen's License

FIREMEN WHO ARE successful in passing their examinations say that if a man knows his subject he will get by the inspector, but if he does not know or tries to bluff, the inspector will surely know it and turn him down. I believe they are correct in making that statement. A lot of applicants are not able to get their licenses the first time and sometimes they are examined two or three times for a second-class fireman license. It seems to me that they do not know the fundamentals of boilers and safety. This must in most cases be a lack of knowledge of what to study. Anybody desiring a license or wanting to fit himself for a higher position must study one subject until he knows it, not going from one thing to another. When a question is asked he must be able to see the object before him.

For a second-class fireman, a man should know the safety of boilers, water column troubles, steam gages, blowoff connections, cleaning and handling fires, starting pumps and inspirator, backwater heaters or how water gets into the boiler. Types of boiler—horizontal, return tubular, vertical, and horizontal water tube locomotive; fusible plugs, kind and where placed; how to clean a boiler, start up, and cut in after an inspection.

Following are some questions and answers that were asked and answered by two successful candidates for a second-class fireman's license:

1. What would be the first thing you would do when you come into the boiler room in the morning?

The first thing to do is to find the water level in the boiler. To do this, open the try cocks, open the drip on water column, also the gage glass drip; this is the ordinary way; the water level in the glass should correspond with the try cocks. To test each gage glass connection, shut the water connection to glass and with the steam open, open drip and if the steam blows through the drip, the top is clear; now close the top and open the water connection, then open the drip, and if water blows through, all is clear. Open the steam, and you may be sure that everything about the water level is all right.

2. If a horizontal return boiler had just been inspected, how would you get it ready, start it up, and cut in with a battery?

See that manhole and handhole plates are in; blowoff pipe protector is on; bricks put inside of rear door and the door shut; fill with water up to second gage (leaving third try cock open to let the air out of the boiler); put on steam gage; then, say 2 in. of coal on the grates; open damper in the uptake; put kindling on the coal, and start it off; this fire shoould not be hurried. When steam comes out of third try cock, close it; when steam gets within 5 lb. of the other boilers, get up to stop valve and as the pressure comes up to pressure in main, open valve slowly. It is very dangerous to cut in a boiler with a difference of 10 lb. pressure. Feed water must be regulated accordingly.

3. What kind of a fusible plug would you use in a vertical boiler, where would you put it, and how get it in?

A short inside or tube plug should be used; this is put in through a handhole into an extra heavy tube, not less than one-third the length of the tube from the lower tube sheet. A socket wrench is used.

4. If the bottom connection between the gage glass and water column was closed, how would you know?

The water would remain perfectly calm in the glass.

5. How can you tell by looking at the gage glass whether the pump is pumping water?

The water will move up and down slightly in the glass.

6. With a battery of boilers, the water is dropping in one. What would you look to first?

See that the feed valves were open to that boiler.

7. If you have a battery of boilers, will all the safety valves pop at the same time?

It is very seldom that more than one valve will pop at once.

8. How do you start an inspirator?

See that the discharge to the boiler is open, suction and both overflow valves open, and starter valve closed. To start, open the main steam valve; when water comes out of overflow, close top overflow valve, open starting valve ¼ turn, close bottom overflow, and water will go into the boiler.

9. What is the vacuum in a boiler? How caused? How prevented?

A vacuum in a boiler is caused by the boiler cooling off and the steam condensing. It may be prevented by opening a vent valve or try cock, which will let the atmospheric pressure in.

10. What harm is there in having a vacuum in a boiler?

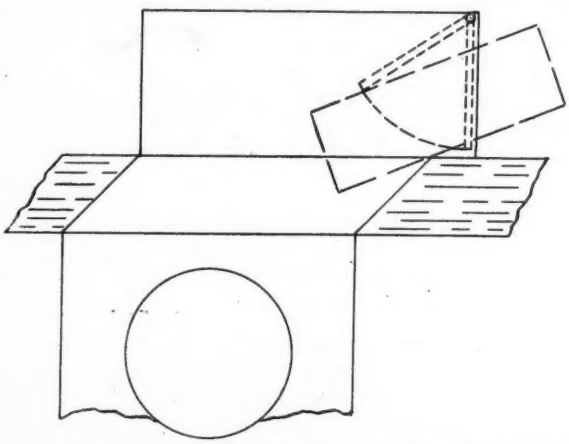
It may bend the pointer on the steam gage, or it may fool the fireman; for, as he opens the glass drop or try cocks below the water level, air bubbles will go up through the glass. When this happens, open some valve on top of the boiler to break it.

W. N. L.

Safety Device for Ice Crusher

In an icecream plant with which the writer was connected, we had several large ice crushing machines installed below the ice storage chamber, and while the openings into the hoppers of the machines were provided with trap doors which were put in place when the units were not in use, there was always present the danger of falling into the machines while feeding the ice cakes when the machines were running.

We therefore devised a protective arrangement as shown in the sketch. The entire opening was boxed



LOCATION OF SHIELD OVER ICE CRUSHER

over with a solid wooden box and then in one end where the ice cakes were to be fed was placed a swinging door, mounted on pivot hinges at the top and slightly weighted at the bottom so that it would tend to swing shut quickly. With this arrangement, the ice cakes were merely pushed against the door which was forced up, but which dropped shut immediately after the cake passed through and the arrangement also prevented the passage of cold air from the ice-room through the crusher openings.

M. A. Saller.

Value of Power Plant Engineering for Reference

To some people, copies of back issues which I have been years in collecting are just ordinary old magazines, out of date. Old, did I say?

Sure they are old (1913) issues, some of them, and the information in them is still older and this is where their real values comes in, because some of the writings and editorials are old established facts and hold just as true today in their meaning as when first printed.

I had occasion recently to set a single eccentric Corliss and not being quite sure on one particular point, I resorted to my books but could not get the idea as I wanted it. I wrote a friend for his "way" and soon after thought of Power Plant Engineering. After a most diligent search, I came across a 1913 issue, and on pages 192 and 193, Feb. 1 issue, found a heading which reads, "A Criticism," and at the end "William E. Dixon."

I think his criticism on question 5, "What is lap on a Corliss engine?" about as thorough and simple an explanation as anybody could find on the subject.

This is only one of the many times I have found help and advice through these columns and this last instance, although it may appear simple, prompted me to offer it as a proof of the value of this magazine as a reference in times of need, especially when help or information may be wanted immediately. I feel well repaid for my efforts in keeping my magazines from being destroyed, and the cost of carting, etc.

I have all my issues from the time I began subscribing for the magazine, and there are few if any of the issues that I should not feel reluctant about parting with. They are to me even better than books, although I have no fault to find with books.

Leroy Blake.

Damper Control

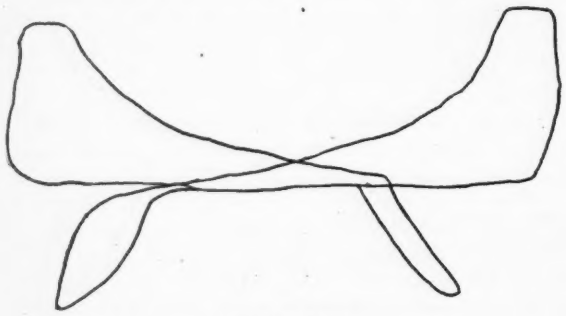
Despite the advances made in operating engineering, it is appalling what small amount of attention is paid to damper control. There is no single piece of apparatus in a boiler room that will pay the return upon the investment as will even a simple hand controlling arrangement in connection with the damper. I have seen where the expenditure of a few cents for material and a little spare time in rigging up a simple graduated control for a damper, has resulted in the saving of hundreds of dollars yearly. It is indeed rare, that a damper is found that cannot be counter-weighted so as to be self-closing—leaving the open position to be adjusted by the fireman.

A number of years ago, the writer witnessed a valuable example of the efficiency of convenient damper control. The plant in question was equipped with certain grate stokers, which, as all know, require coal of small size. During the coal shortage, considerable lump and mine run coal was delivered to the plant. After a few weeks, the crusher began to wear so as to pass coal as large a size as 3 in. It was during the yearly peak condition and as it would require several days to repair the crusher, it was necessary to operate stokers using the large size coal. Now, those having had experience along this line know that with large coal on this type

of stoker the fire will leave the grate and the conditions in general are bad. The boilers in this case were equipped with very convenient hand-controlled dampers, with the operating mechanism close to the stokers. The fireman could, therefore, adjust the damper opening to suit the size of fuel under the arch. The result was that although there was a 30 per cent drop in capacity, the boiler efficiency suffered very little; all due to the close damper control. JOHN F. HURST.

A Freak Indicator Card

WHILE indicating my engine (which is a four-valve Greene) some time ago, I discovered that I was getting the peculiar diagram shown herewith. I wondered what



A FREAK CARD

could have happened and as everything about the engine was all right, I decided that the trouble must be in the indicator, and when I had it apart, found a broken spring. This may be of interest as a freak card.

W. N. L.

What is a 45-Deg. Elbow?

N. G. NEAR, in Feb. 1 issue of Power Plant Engineering, on "What is a 45-Deg. Elbow?" according to my way of thinking has the cart before the horse, in his reasoning. My idea is, that the deviation from a straight line names the degrees of the fitting. If he will go by the deviation from straight line, he will find that in Fig. 1 the angles A O C and B O D are 45 deg. while, in Fig. 2, the angles A O C and B O D are 135 deg.

A 45-deg. elbow is called such because when used a 45-deg. elbow turns the straight line of pipes 45 deg. from that originally started. I would also reason, on this same line, with a 90-deg. elbow. C. D. SHARPE.

N. G. NEAR applies the name "misnomer" to the 45-deg. elbow. A 45-deg. elbow looks like Fig. 1 of his letter because it actually is 45 deg. of one circle, measured around the circumference. Suppose we accept N. G. Near's view of the matter, that Fig. 1 is a 135-deg. elbow. It will require eight of these elbows to form a circle; $8 \times 135 = 1080$ deg.

As far as steam fitters and plumbers are concerned, many of them do not refer to elbows or bends by degrees, but as ⅛ or ¼; however, practically every mechanic who uses 45-deg. elbows knows that it is 45 deg. of the circle that is meant.

Answering the question asked in the letter, a 45-deg. elbow is ⅛ of a circumference. JAMES E. NOBLE.

WORKING AT the piping game, I was interested in the article, "What is a 45-deg. elbow?"

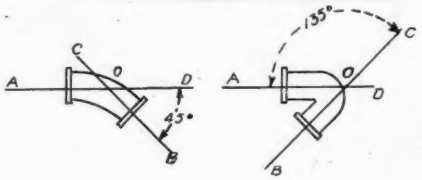
I have drawn a 45-deg. angle to help express my idea of it. As I look at it, a fitting is made from the outside of the circle and not from the center. From A to B, not from O to B or A. CHAS. L. RAWSON.

ANOTHER PIPE fitter thinks that the name "45-deg. elbow" is absolutely and naturally correct, indicating a deviation of 45 deg. from the straight flow.

H. J. HEYRODT.

I DO NOT agree with N. G. Near that the name "45-deg. elbow" is a misnomer, for it names specifically the arc of the circle or bend between which such a pipe fitting is to be used.

In Fig. 4, I have shown at D, the illustration of Fig. 1 of his article, set between the lines drawn from the center to the circumference of a 45-deg. arc of a circle. I have always been told that the fittings were 45 deg. of the circle whether 45-deg. elbows or elbow bends, and in ordering, it is necessary for elbow bends, to give measurements from face to face of the flanges as illustrated in Fig. 4 and all catalogs I have seen give such dimensions. The fittings are all measured from arcs or angles in inches or degrees and with many bends both arcs and angles are used to get proper measurements. I cannot conceive how anybody who would use the angle A O B and draw a circle from the point O as the center, which would equal 135 deg. between A and B, could expect to use such measurement in laying out a single offset quarter bend piece of pipe which would require the use of arc oblong, square or quadrangle to start from.



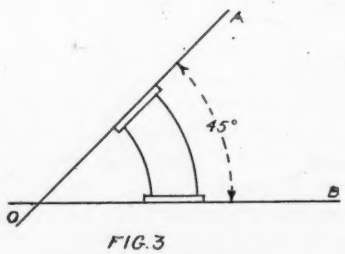


FIG. 1. 45-DEG. ELBOW

FIG. 2. 135-DEG. RETURN BEND

FIG. 3. FACES OF 45-DEG. ELBOW ARE AT AN ANGLE OF 45 DEG.

Mr. Near's Fig. 2, I have place at E in my illustration in the circle Fig. 4, as I cannot at present see from what point or angle he would start to lay out the dimensions of such a fitting. The only one of this type I have ever seen was a drain fitting as I have shown in Fig. 5, with a side outlet. This fitting would come under the class of laterals and angles.

Referring to the fitting E in Fig. 4. The lines drawn across the face of the flanges P and Q form the same angle as the line A O B on the 45-deg. elbow and to measure it the same, to have the flange or thread come at the proper angle it would make a fitting with 135-deg. elbow. Now an elbow does not exceed 90 deg. As I have shown, 1 and 2 are 5⅝-deg. elbows, 3 is an 11¼-deg. elbow, 4 is a 22½-deg. elbow, 5 a 45-deg. elbow, 6 a 60-deg. elbow, all of which are on the market as steam, water or drainage fittings. From 135 deg. on the circle to 120 deg. is shown a 15-deg. elbow and number 7 is a 30-deg. elbow. This completes one-half of the circumference of the circle of 180 deg. and therefore makes a complete wide or open return bend.

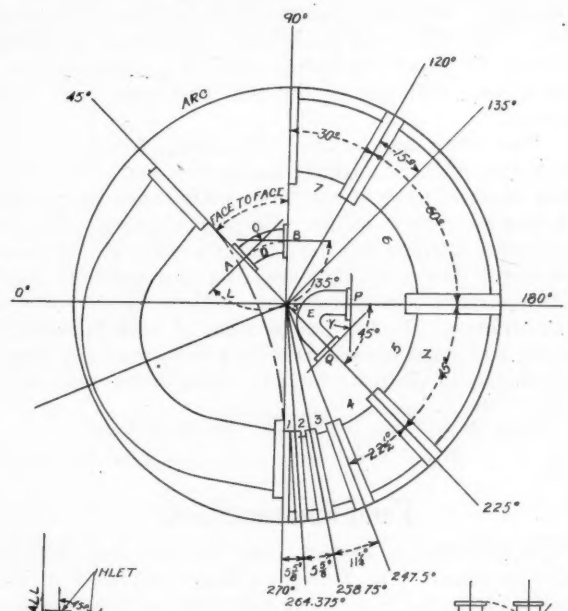


FIG. 5

FIG. 4

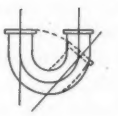


FIG. 6

FIG. 4. DEGREES OF PIPE ELBOWS
FIG. 5. SIDE OUTLET REDUCING LATERAL
FIG. 6. U RETURN BEND PARTLY SUPERIMPOSED BY E OF FIG. 4

A complete U bend is shown in Fig. 6 with the two parallel vertical center lines at right angles to the flanges and placing fitting E on Fig. 6 would give a flange as the dotted line shows. The lateral 45-deg. center line is the same as a single side outlet or inlet of a Y fitting, and the line drawn across the face of the flanges is the same as O and Y in fittings D and E in Fig. 4. Now apply the flanges of Mr. Near's Fig. 2, fitting to the circle and they will make, according to present measurements of pipe fittings, a 135-deg. return bend as at X in my sketch, and as seen by the arc of the circle from 45 to 90 deg. It would require only 45 deg. to complete the half circle and make this a U bend. I would therefore call this E fitting a 135-deg. return bend as any fitting covering more than 90 deg. of the arc of a circle is returning in the same direction in a fractional part of the arc of the circle which the bend covered. And the angle of the flanges can be more easily computed.

There are many different kinds of pipe fittings and I think the manufacturers have done well in so standardizing as to have the names of the same arcs or angles indicate a kind of piping in which they are to be used, for instance, generally speaking, one expects the elbows of threaded or flanged pattern to apply to steam or water service of medium pressure, and other names for other pressures and service, such as gas fittings, plain malleable iron, ammonia, extra heavy meaning high pressures and long bends, hydraulic and sprinkler, also high pressure, and liquid, air pipe fittings for special high pressures and used with gases of similar characteristics. While drain piping has all conceivable bends and angles imaginable, such as 1/16 bend, ⅛ bend, ¼ bend (no short elbows), ½ or Z bend with as many outlets or inlets and cleanouts as may be needed. Why reverse the angles and arc to confuse beginners?

R. A. CULTRA.

Steam Wasted by Loose Dashpot

A WEEK after taking charge of an industrial plant engine room, the chief engineer was called out of bed to replace a gasket that blew out of a steam line. On finishing up the job and starting up, the handy man around the plant was called in to run the engine and boiler until the chief could go home to breakfast.

On returning to the plant, the chief noticed steam was low and immediately started to rush the fires, but to no avail, the steam kept going down. He looked carefully around to find whether any valves had been opened, and went to the engine and listened to the working of the valves. Steam could be heard rushing through the valves and a healthy exhaust was also noticed. The engine was a Slater, and on the head end, the dashpot was found loose on the valve stem and at every stroke was gradually unscrewing off the valve steam, thereby lifting up the valve until the valve was admitting steam continually. A few turns with the hand and a wrench on the lock nut soon fixed the trouble without shutting down, the valve being set correctly for steam seal later.

ABIE MALLALIEU.

Beware—The Boll Weevil

TOO MANY MEN, under whose supervision the operation and maintenance of power plant equipment are placed, are wont first to employ a man and try him out with the expectation that he will fill the bill. If he proves worthless, it necessitates doing the job all over again, which not only has cost your time but possibly has cost your firm money. This proceeding may happen several times before you find the right man and, meanwhile, what have these green or unfitted men done with your equipment?

Carelessness or ignorance have played hob with it; and whose fault is it? Yours, of course. The man might have been well equipped mentally to handle the job in question, but through carelessness, laziness, or ignorance of the meaning of discipline, things have gone wrong.

There are many ways in which you can judge the man you are employing before he is even put on your pay-roll and these will materially help the labor turnover that is ever present and which costs, really, several thousands dollars annually in cold cash or ruined equipment.

You do not necessarily have to be a student of human nature to any great degree to put these simple methods into practice and they will always pay dividends to you and to your firm.

Naturally, you are more interested in whether a man possesses sufficient experience to handle your certain job in the way it should be handled rather than whether he has the personal qualities and initiative of which some men are entirely devoid. You rely too much upon your being able to instill into the man you hire the pep and headwork necessary to handle his job to your satisfaction, by talking it into him whether he has the capacity to absorb it or not. Very few men are able to absorb such things if they do not already possess them to a certain extent, and ten to one it will all flow into one ear and out of the other. The man will mentally form a very flattering opinion of your ability to chew the rag. Unless you follow him up concerning every word of such a training course and drive him into seeing that you mean business, you have lost out from the very beginning. Some men cannot see the necessity for discipline in a power plant, or for that matter, pep or initiative, and when you do attempt to drive these facts home, they take the matter personally and either quit you or are discharged because of their insubordination.

Now, as an example: You have advertised for a fireman. Two applicants are waiting outside your office and you call them in, one at a time, to ascertain their qualifications.

Applicant number one enters without removing his hat and the first thing you notice is his unkempt appearance. He advances to where you are sitting and thrusts out his hand, announcing, in a loud and raucous tone and wholly intelligible manner that his name is John Zxcibnossd and that he is ready to start work at once. He notices an unoccupied chair at your side and immediately after shaking hands with you, makes himself comfortable in it. Pulling a cigarette from somewhere in his clothing, he lights it and fills your office with cheap smoke. For fully five minutes you listen to a glowing account of what he has done and what he can do. He tries to give you the impression that he is better than the average man and for that reason will not work for the average man's wages. While he has been talking, you have your opportunity to form an opinion of this man. An opinion that will either save or cost your firm part of that several thousand dollars above mentioned.

His manner and conversation will tell you this: His appearance will indicate that since he is careless with his person, thus he will be with your equipment. He thrusts his hand upon you, making you feel that you are his equal, mentally, morally and physically, boss or no boss. This man knows no discipline. He mumbles his name as if it shouldn't be necessary in the transaction and in a manner that makes you wonder why you have never heard of it before. This gives you an insight into the fact that he is subject to a severe case of egotism. His recital of his sterling qualities and the number of big jobs he has held down in the past year confirms the foregoing opinion. He informs you that he is ready to go to work at once, making you feel that here is a man for whom you have been looking for ever so long and making you wonder if you hadn't better grab onto him before it is too late; more egotism. Uninvited, he seats himself in one of your chairs, bringing to light the fact that he is lazy and a seat-warmer, beyond hope. Then, he openly shows you that he is an indiscriminate smoker and that even if the firm have posted rules against smoking in the plant, he will, at the first opportunity, find some way of breaking them, unseen. And seeing that he is such a good man, he offers to come to work for you at a wage way above your allowed schedule, even though he has been out of work for several weeks. He feels, however, that he couldn't afford to work for less because he has so many expenses, etc. (including a car, probably).

Now, would you hire this man if you viewed him in this light? Of course you wouldn't, but you do it every day. You do not look beneath his swagger and strutting because he puts it in such a subtle way; however, you learn later that this is the man who costs your firm money.

The other man enters. He takes off his hat and makes no attempt to shake hands with you. He shows first hand evidence of careful grooming even though his clothes are rather shabby. He proves himself polite at all times, keeping his feet and standing at attention while *you* do the talking, answering your questions manfully without any attempt at egotism, bluster or untruthfulness. He, too, has been out of work for several weeks and states himself as willing to start at any wage, relying upon his own efforts to obtain better remuneration in the future.

This is the man you want. Think it over.

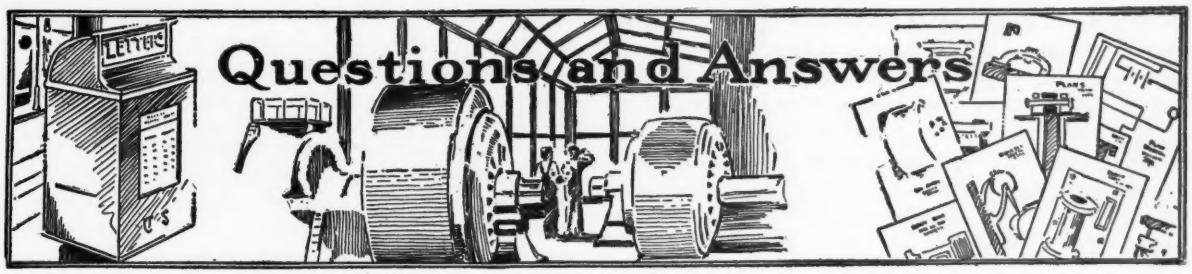
J. W. Shaw.

Fatal Electric Shock

Attempting to quench a fire that had started from a short circuit, Abe Ericson, a miner employed at the Big Cottonwood mines near Salt Lake, grabbed a metal bucket containing water and pitched the contents upon the blaze. The current, following the path of least resistance, backed into the stream of water, bucket and then through the unfortunate man, killing him instantly.

J. B. Dillon.

U. S. Civil Service Commission announces an examination, receipt of applications to close March 29, for electrical and mechanical aid, to fill a vacancy in the Public Works Department, Naval Air Station, Pensacola, Fla., at $7.60 a day, plus increase granted by Congress of $20 a month, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries. Duties will consist of the design and supervision of construction of all electrical and mechanical work coming under the cognizance of the Public Works Department, embracing underground conduit system, electric and telephone distributing systems, central power plants, indoor and outdoor substations, electrically driven centrifugal pumping stations; installation of cranes, hoists, compressors, ventilating equipment; compilation of reports, making of estimates and administration of contracts, as civilian assistant to the Public Works Officer. The minimum age limit does not apply to persons entitled to preference because of military or naval service. Apply for Form 1312, stating the title of the examination desired.



What is the Cause of the Low Initial Pressure on One End of the Cylinder?

WHY IS the initial pressure so much less on the head end of the diagram shown herewith, than on the crank

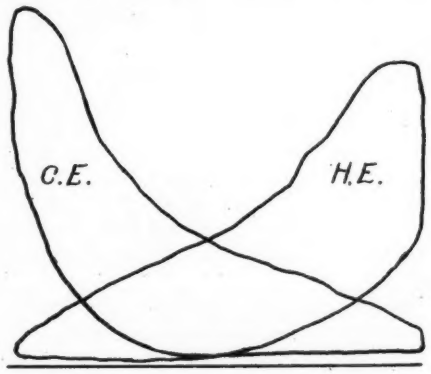


DIAGRAM FROM A MC EWEN ENGINE

end? This card is taken from a 12 by 13-in. McEwen engine operating on 125 lb. gage pressure and running at 275 r.p.m. C. W. B.

Massachusetts Examination Questions

CAN YOU answer these questions? If you can, let others have the information.

1. If you were inspecting a boiler and found a stamp "Indian Head Cast Steel, 60,000 T. S.," what process would you suppose this steel had gone through in its manufacture? Also C. H. M. No. 1 Flange.

2. Supposing one of the check valves on a Smith setting stuck, then how would water circulate in the generator pipe on that side?

Would you require stop valve between check and boiler with this setting?

4. Describe a Dean boiler. J. A. H.

Water Rate; Fan Efficiency

THE FOLLOWING DATA refer to a single-cylinder steam engine: Sectional area of cylinder = 200 sq. in.; stroke, 24 in.; clearance volume, 7 per cent of piston displacement; steam is cut off at $\frac{1}{r}$th of the stroke; r.p.m., 110; initial pressure, 105 lb. per sq. in. abs.; back pressure, 15 lb. abs.; actual i.hp. = 140; density of steam at 105 lb. = 0.236 lb. per cu. ft.; actual weight of steam used per i.hp. per hr. = 30 lb.

Determine the value of "r" (between 3 and 4) and the steam per i.hp. per hr. unaccounted for by hypothetical diagram, if the expansion is hyperbolic and the volume of the clearance steam, after comparison to initial pressure at the beginning of forward stroke by the incoming boiler pressure is 0.01 of the piston displacement.

2. An electrically driven fan designed to deliver 24,000 cu. ft. per min. of air at a pressure of 2 in. of water when running at 700 r.p.m. is to be put into a power installation to assist in the draft. What temporary arrangements would you make for testing the fan at the works? The outlet from the fan may be assumed to have an area of 6.5 sq. ft. and is square; the density of air is 0.08 lb. per cu. ft.; the velocity head is 0.9 in. of water, and input hp. 17. What is the total mechanical efficiency of the fan? C. B. H.

ANSWERS

IN ORDER to find the point at which the cutoff occurs in the example you give us, we first solve for the mean effective pressure, which we get from the equation

$$\text{hp.} = \text{PLAN} \div 33{,}000$$

Substituting in this equation the figures you give us we have

$P = (140 \times 33{,}000) \div (2 \times 200 \times 220) = 52\frac{1}{2}$ lb. per sq. in.

To find a card whose mean effective pressure is this amount, it was necessary to draw a hypothetical indicator with 7 per cent clearance volume, 15 lb. back pressure and assume, for instance, a $\frac{7}{8}$ cutoff. After constructing the diagrams with cutoffs ranging from $\frac{1}{4}$ to $\frac{1}{3}$, we find that the cutoff giving a mean effective pressure of $52\frac{1}{2}$ is 30.8 per cent of the stroke, in other words, r = 3.25.

The water rate accounted for by a diagram is (per cent cutoff × the displacement × the density at cutoff pressure plus the clearance volume × the density minus 0.01 of the displacement × the density) × (the r.p.m. × 60 ÷ i.hp.). This reduces to (0.368 × 1.39 × 2 × 0.2365) × (220 × 60 ÷ 140) = 22.796. The actual water rate being 30, as you say, this gives the water unaccounted for as 7.21, and the per cent of water unaccounted for in the diagram is 24.

2. To make a test on a blower, it would be necessary to set up the blower with a convenient duct where the pressure can be measured and connected up with a motor supplied with the necessary instruments for measuring voltage. amperage and speed, the duct should be provided with a differential and static gage to record velocity and static pressures. The work done by this fan is, according to the data you have given us, as follows:

H. P. equals the velocity times the area times the

static head in lb. per sq. ft. divided by 33,000. Velocity equals $\sqrt{2gh}$. 0.9 in. of water equals 58.5 ft. of air, the air density being 0.08, as you have given. Substituting this value in the above equation, we get:

Velocity $= \sqrt{64.4 \times 58.5} = 61.3$ ft. per sec., or 3678 ft. per min. Hp. $= 3678 \times 0.9 \times 62.5 \div 12 \div 33{,}000 \times 6.5 = 3.39$.

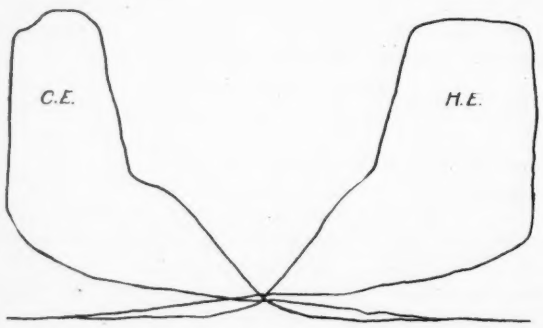
The efficiency of your blower is then

$$\frac{3.39}{17} = 20 \text{ per cent.}$$

Suggested Improvements

REFERRING TO the indicator card from a 14 by 22 in. riding cutoff engine submitted by A. S. in the Jan. 15 issue of Power Plant Engineering, it appears as if the riding cutoff must be entirely out of commission, as it is apparently nothing more nor less than an ordinary slide valve diagram. Indications are that considerable repair work could be done to advantage on this engine. The exhaust pressure is high as compared with the admission pressure and the head end develops a leak with an accumulation of compression pressure. The crank end has rather too much compression for 74 r.p.m.

H. A. C.'s card is what I would call an approach to the perfect practical card. Except that the head end carries slightly the greater load, due to a longer cutoff,



INDICATOR DIAGRAM FROM A REYNOLDS-CORLISS ENGINE, 26½ BY 60 IN., RUNNING 63½ R.P.M.

no fault can be found and no improvement can be suggested other than to make the points of cutoff more nearly equal.

The diagram produced by L. C. T. shows that a little more care and patience could well be employed in cutting and trying in order to get the valves to make regular and correct periods. The admission is rather late on both ends. This condition could be remedied by advancing the eccentric, which would also increase the already high compression. This could be relieved by removing about 1/16 in. from the inside or steam lap.

As for C. R. D.'s card, I would say that there is something radically wrong with his reduction motion and indicator which should be corrected before any attempt can be made to criticize the operation of the valves. One cannot be too careful or painstaking in adjusting the reducing motion and cord tension of an indicator so that there will be a clear field at each stop of the drum and as little lost motion as possible at the reversal of the stroke. It should also be borne in mind always that an indicator diagram is, at best, nothing more than an approximation of the actual conditions in the cylinder.

The cards produced by T. J. M. are certainly curiosities. I have a Reynolds-Corliss engine 26½ by 60 in. 63½ r.p.m., that gives a similar card. It is reproduced herewith for the consideration of T. J. M. or any of your readers who wish to explain the really curious. A discussion of this diagram will be appreciated.

S. A. S.

Water in the Exhaust

WE WOULD LIKE some information concerning our steam plant here which pulls the local electrical plant. We have a 75-hp. Huston, Sanwood & Gamble engine of the old design. This engine is working from a 100-hp. return fire-tube boiler.

Our engine when running throws out through the exhaust a dense spray of water, the exhaust going through a heater. What is the cause of this and what would be the most economical way in which to remedy it?

2. It seems that our furnace will fire better some nights than others. What causes this? A portion of our smokestack broke off. Could this cause the interference? Would forced draft be of any advantage to this furnace?

3. We are thinking of enlarging our flywheel on this engine to slow it down and lessen the exhaust. Wouldn't this show a big saving in fuel? It is running 300 r.p.m. at present; about how slow would you advise to run it so as to develop full power?

4. We have our alternator belted to this engine and the exciter belted to the alternator (alternator being 2300 v., 60 cycle, 3 phase). Our lights seem to flicker slightly. Could this trouble come from the governor of the engine? All belts and connections are in good shape. What would you suggest to correct this fault?

5. We have one resident consumer on a 120-v. circuit who is receiving pretty severe shocks in touching any electrical device in his house, such as lamp socket, switch plate, iron, etc. None of the neighboring consumers seem to be having any trouble at all; also, in holding the drop cord of each light, a small vibration will be felt. We have looked for "shorts" and find everything looking very good. What could be the trouble?

L. G. W.

ANSWERS

THE SPRAY from your exhaust would indicate that the heater is not properly dripped. You do not state whether this is an open or closed heater so we will presume that it is a closed heater and in that case there should be sufficient drip pipe to carry away the steam condensed in the heater. It may be, however, that you will have to put an exhaust head on top of your exhaust pipe to catch the water in the exhaust steam so that it may be dripped back to some point where it will do no harm.

2. Whether forced draft will help your furnace or not, we cannot say without having further data as to the size and height of your stack, size of grate, and the amount of coal that you are burning. The chances are that if a part of the smokestack is gone, the difference

in burning of the fire is due to the direction of the wind. You can tell this, of course, by watching a while to see if a good draft is always with the wind in the same direction; of course any fire will burn better on a cool, clear night than when the outside air is rather warm and moist.

3. As to using a larger flywheel and slowing down the engine, we do not see how this would be of any advantage. If you slow the engine down to furnish the same power, you would have to lengthen the cutoff, which would mean the same amount of steam used, only that you would have more steam per revolution and fewer revolutions, or else you would have to increase your boiler pressure considerably in order to get the same amount of energy into the steam which went to the cylinder. It is, of course, a question of whether your boiler is in condition to stand the increased pressure.

4. Flickering of your lights may very probably come from lack of sensitiveness in your governor although with as high speed as 300 r.p.m. this does not seem likely. Possibly adjusting the governor so that it is a little less sensitive will remedy the trouble.

5. As to the consumer who is getting shocks from his electric circuit, it would seem that he must have a ground somewhere in his wiring on one side of the circuit. In that case, when he stands on the ground and touches the other side of the circuit he will, of course, get a shock. The fact that no other consumers are having trouble indicates that he has a ground somewhere on his premises. You can test with a voltmeter from a water pipe, first to one side of the circuit then to the other. On the grounded side there would be little or no voltage reading, while on the other side there would be nearly full voltage reading.

Carrying Capacity of Spring Arches

WILL YOU kindly tell me how to figure how much more load per square foot an arch will support than a flat surface supported on ends, of course?

To give you the exact problem, we are putting a floor in one corner of the engine room, and to support this this section, 16 ft. 2 in. wide by 18 ft. long, we are installing five 8 in. I beams 16 ft. 8 in. long, spaced 4 ft. 8 in. on centers. These we plan to tie together with ¾-in. bolts and then to spring an arch of corrugated sheet steel to take the weight of the concrete floor, pumps, etc., that the floor will carry. The sheet steel will have a 6 in. spring to arch. How much more load will this carry than a sheet of steel laid from top of one to top of next? Can you give me a formula for this? What safe load per square foot will 20 gage corrugated sheet steel ⅝ in. deep by 25 ft. wide by 4 ft. 8 in. long support?

2. One of the repair men in the plant asked me if it will be easier to maintain pipe lines and boilers on 40 to 50 lb. pressure rather than 100 lb. When I agreed, he asked me why we did not double the area of the piston and cut the steam pressure in two, making repairs, wear and tear so much less. I was conscious that my arguments had a rather unconvincing note. Kindly help me out. C. A. W.

ANSWERS

WE DO NOT SEEM to find any data in regard to the amount that arching plates will increase their ability to carry a load. Kent states that the arching is found to increase the carrying capacity considerably, that this arching is usually from 4 to 10 in., the increase in capacity being proportional to the height of the arch and that the span should be under 5 ft.

What you propose is, therefore, in line with good practice, but just how much you will gain in carrying capacity we do not find stated, nor is there any rational way of figuring it; I am, however, writing to manufacturers of corrugated roofing material to see if they can give any data and will let you know later.

2. As to the comparative life of pipe line with low and high-pressure steam, the only thing which would make a difference, so far as we can see, is the greater expansion and attraction of high-pressure steam which would tend to open up the joints and call for more frequent repacking.

As to the economy of using the low-pressure steam, of course the number of pounds of steam that you can send through the pipe would be much greater for high pressure than for low pressure and the power which you can get from a given engine or turbine is much greater for high-pressure steam than low-pressure. This would mean that for a given amount of power to be generated you would have to have a much larger engine with low-pressure steam which, of course, would be much more expensive and you would have to make more pounds of steam which would call for more coal.

There is some more radiation from the high-pressure steam than from the low-pressure, but with a well insulated pipe this increase is not very great.

Work Capacity of Hoisting Engine

WHAT WEIGHT will this hoisting engine start or lift? Steam pressure 110 lb., diameter of cylinder 14 in., length of stroke, 16 in. There is a pinion on the crank shaft having 20 cogs or teeth which meshes with a gear of 100 teeth on a shaft with a drum 2 ft. in diameter. The tackle has one movable block. This is a double engine, common "D" slide valve, no flywheel.

D. D. L.

A. To determine the amount of load which the hoisting apparatus you have indicated to us will lift, we will equate the work done at the engine to that at the block.

The work done per revolution of the engine equals P. L. A. Where P is the mean effective pressure, L is the stroke in feet, A is the area of the piston in square inches.

We will assume for want of better data that the engine takes steam full stroke and that therefore the mean effective pressure will be the same as the steam pressure, 110 lb.

Work equals $110 \times 16 \div 20 \times 3.14 \div 4 \times 14^2 \times 2 \times 2 = 90{,}400$ ft.-lb. per stroke.

For one revolution of the crank, the drum makes 1/5 of a revolution and travels 3.14×2 ft. $\div 5$ and the block moves half of this distance, or 0.628 ft. Assuming 100 per cent efficiency, the work at the block is 90,400 ft.-lb. per 0.628 ft. of movement. Therefore the weight that the block can handle $= 90{,}400 \div 0.628 = 144{,}000$ lb. $= 72$ tons. Assuming a 60 per cent over-all mechanical efficiency, this becomes 43.2 tons.

Loss Due to Friction

PLEASE GIVE the formula for finding friction head loss in pipe? F. R.

A. The formula for finding the friction head loss in a pipe is as follows:

$$h = 0.03\ Q^2 \div D^5$$

Where Q is the discharge in gallons per minute, D is the actual inside diameter of pipe in inches, and h is the pounds pressure loss per 100 ft. length. In your case, Q = 30 and D for a 2-in. pipe = 2.067 in.

then $h = 0.03 \times (30)^2 \div (2.067)^5$

$h = 0.03 \times 900 \div 37.8 = 0.715$ lb. per sq. in.

head loss in ft. of water $= 0.715 \times 144 \div 62.5 = 1.65$ ft. For a 2500-ft. pipe, this would amount to 41.3 ft. head. The lift for the pump will then be 10 + 70 + 41.3 = 121.3 ft.; 30 gal. at 8⅓ lb. per gal. = 250 lb., so that the work done per min. will be $121.3 \times 250 = 30{,}350$ ft.-lb.

Dividing this quantity by 33,000, the ft.-lb. per min. equivalent to 1 hp., we get hp. $= 30{,}350 \div 33{,}000 = 0.92$ hp.

Assuming a pump efficiency of 75 per cent and an engine efficiency of 75 per cent giving a combined efficiency of 56.25 per cent, divide 0.92 by 0.5625 and we get 1.635 hp. for the engine.

As a gas engine has practically no overload capacity beyond rating, it would be well to provide an engine of at least 2¼ hp. to take care of emergencies.

Changing Plant Voltage

WE HAVE at our plant a direct connected alternating current generator 600 v. 435 amp., 120 r.p.m. This unit has been run at an average of 570 v. We may decide that we wish to change this unit from this voltage and step it down to 220 v., due to the fact that we have another 220-v. unit in our plant and wish to have all of our motors of the same voltage. The writer of course realizes that by doing this, different gage wire will be required, also transformers and so on, and we would be glad if you will inform us of the advantages and disadvantages of stepping this unit down.

J. A. K.

A. In reply to your question, we will state that the main advantage in reducing the voltage of your 435-amp. alternator would be to secure a uniform voltage throughout your plant and thus allow a standardization of your motors. As it is, you are unable to operate your 570-v. motors on your 220-v. circuits.

It would, of course, involve some expense to provide means whereby you could secure 220 v. from both of your machines but we believe that such expense would be warranted by the increased convenience and the reduced cost of carrying repair parts for two different voltage machines.

Just what would be the best way to provide 220 v. from your 570-v. machine is somewhat difficult for us to state, but two means are available: The machine may be rewound or else a transformer installed to step down the voltage from 570 to 220 v. In view of the fact that your generator has undoubtedly been designed to deliver a voltage of 570, it might be better to provide a transformer for this service.

Ammeter Out of Calibration

WE HAVE HERE a 2200-v., two-phase, 27-amp. circuit. Does this mean 27 amp. for each phase or for both phases.

2. There are two ammeters on the switchboard. When the current is off the needle stops at 5 amp. and does not fall to zero. What is the cause of this?

A. C.

A. When speaking of a two-phase circuit carrying 27 amp. at 2200 v., we generally mean that each circuit is carrying 27 amp., or with a balanced load, 54 amp. for the system.

2. Just why the hands of your instruments should stop at 5 amp., we cannot state definitely. It may be due to the meters becoming slightly out of adjustment and, again, it may be because of the capacity effects of the connected transmission system. Of course, if the instruments indicate 5 amp. with the line entirely off, then evidently the meter is out of calibration.

What is the Cause of Boiler Pitting?

WE HAVE a battery of return tubular boilers, the tubes of which are pitting and scaling badly, and it, to my mind, is due to one of two causes—galvanic action or excess air in the feed water. How can I determine which?

The boilers, according to the insurance inspector, are "too clean." Nearly all of our feed water is condensate, very little build-up water is needed. Part of the condensate is from exhaust steam, but an oil separator is used. We have an unusual amount of brass and copper in heaters and the feed water line. For example, from the pump and heater the feed water is driven through about 50 ft. of 2-in. brass pipe to each boiler. What in your opinion is the cause, and what the remedy? I find no acid reaction in the feed water.

B. S. G.

Voltage Regulation

WE HAVE in our plant a 2,000-kw. turbo-alternator which is not provided with a voltage regulator. Should the voltage be regulated with the field or exciter rheostat? B. W. D.

A. It is usual to hold the voltage on the exciter constant and regulate the excitation of the a. c. generator by means of the rheostat in the generator field. This is absolutely necessary in case more than one alternator takes field current from the same exciter.

Correction Note

IN THE ANSWER to the question, "What is the equivalent evaporation when a boiler evaporates 1900 lb. of water per hour, the gage pressure being 115 lb. and the temperature of the feed water 80 deg. F.?" which appeared in our Feb. 15 issue on page 245, the equation for the factor of evaporation is given: $(1191 - 80 + 32) \div 970.4 = 1223 \div 970.4 = 1.261$. This equation should of course read $(1191 - 80 + 32) \div 970.4 = 1143 \div 970.4 = 1.177$. This is an evaluation of the equation $F = H - q_2 \div 970.4$. The equivalent evaporation will then be $1900 \times 1.177 = 2236$ lb. per hr., and the horsepower developed will be $2236 \div 34.5 = 64.8$ hp.

Measuring Pressure with a Thermometer

IS THERE any rule by which you can find out how many inches of vacuum a turbine or reciprocating engine is carrying when no vacuum gage or mercury column is attached? J. K.

A. It is possible to measure the pressure of the steam exhausting from an engine or, as you say, the vacuum the engine is carrying, by putting a thermometer in the exhaust line and reading the temperature. From this temperature you can find the corresponding absolute pressure in pounds per square inch by reference to a steam table. This pressure can be converted into absolute pressure in in. of Hg. by multiplying by 2.032. To get the in. vacuum, subtract this from barometric pressure.

For instance:

Temperature of steam = 125 deg. F.
From steam tables absolute pres. = 1.95 lb. abs.
Absolute pres., in. Hg. = 2.032 × 1.95 = 3.96 in.
Assuming barometric pres. = 29.75 in.
Vacuum = 29.75 — 3.96 = 25.79 in.

Correcting Power Factor by Using a Synchronous Motor

WE HAVE in our plant, which is engaged in the manufacture of sugar, a horizontal turbo-generator furnishing the electric power; the generator is rated at 450 kw., exciter 15½ kw., 125 v., 80 per cent power factor, 677 amp. 480 v. at full load. 3000 r.p.m. Operating conditions are: exciter voltage 125 v., generator 460 v., maximum load 900 amp., average power factor 79 per cent.

Power tests on the several circuits during the day total 488 kw., which runs up to about 512 when the lighting load comes on.

The machine is in A1 condition mechanically; the generator shows no sign of distress in any way, running perfectly cool even on the hottest days, and two of the steam valve ports have never been open.

We also have a direct connected reciprocating alternating set rated at: 168 kw., 254 amp., 480 v., 80 per cent power factor, 214 r.p.m.

This unit we do not use except for irrigation when the remainder of the plant is idle.

We would like to add about 65 kw. to our maximum load, direct connecting several centrifugal pumps and other machinery now carried by a seriously overloaded Corliss engine; would it be possible to use, economically, the 168 kw. machine as a synchronous condenser, correcting power factor and enabling turbine to handle the additional load?

Would say further that there are several installations about the factory running under conditions favorable to synchronous motors; one is a 6-in. centrifugal ammonia condenser pump, consuming 20 kw.; the other is a 6-in. centrifugal, delivering water to a supply tank and consuming 50 kw.; the first is on a circuit averaging 200 kw., the second on a 92 kw.; the alternator is in the power house. W. E. L.

A. The turbo-generating unit which you have in your plant has, according to the data given us, a rated capacity of 450 kw. You have not so stated, but we presume from a check we have made on the ampere and volt rating of this machine that it is a three-phase unit, and so find that according to the operating conditions mentioned, the load on this machine is 703.8 kv.a., or with a power factor of 0.79, 556 w. It is thus evident that your machine is carrying a load of 106 kw. in excess of its rated capacity, or, in other words, is ordinarily operated at nearly 125 per cent rating.

Accordingly, it would hardly be advisable to connect an additional synchronous motor to this unit for then the load might be such as to cause more or less trouble. You will realize that while the addition of such a synchronous motor might result in the correction of your power factor and a decrease in your kv.a. load, the actual load in kilowatts would, however, not be decreased but rather increased. We would, therefore, not recommend the installation of the synchronous motor.

Distance Between Pulleys

WHAT RULE or rules are most used for determining the distance between the driving pulley and the driven pulley of machines? INQUIRER.

A. There is no hard and fast rule for determining the distance between pulleys.

The minimum distance is usually considered to be about two times the diameter of the larger pulley. The maximum distance rarely exceeds 60 ft. If the distance is over this, rope drives are usually used. The short distance between pulleys requires an exceedingly tight belt to effect sufficient tension to transmit the power. Belts in this kind of service are usually short lived. The drive side of the belt should always be on the bottom so as to obtain the maximum angle of contact possible. Horizontal drives are better than vertical drives for this same reason.

Clearance Practice

WHAT SIZE should a 5½-in. axle be larger than the hole in the wheel for 30 tons to put it home?

2. How much smaller should a piston valve be than the housing or seat, and not leak steam or become tight by expansion?

C. D. B.

A. The tolerance allowed for a force fit on a 5½-in. axle is +0.006 to +0.009 in. The sliding piston valve should have clearances as follows:

Diameter, inches	Clearance, inches
½	—0.00025 to —0.0005
1	—0.0005 to —0.0001
2	—0.0001 to —0.002
3½	—0.002 to —0.0035
6	—0.003 to —0.005

Steam Economy and Pressure

WHICH WOULD be the most economical in fuel, using steam at 160 lb. pressure or at 140 lb., and why? What would be the per cent of fuel saved, assuming all other conditions equal? H. C.

A. It will cost slightly more to make steam at 160 lb. pressure than at 140 lb. The total heat at 160 lb. is 1196.9 heat units and at 140 lb. 1195.2, making a difference of 1.7 heat units, or 0.14 per cent.

Used in an engine, however, you will increase the possible heat efficiency of the engine exhausting at atmospheric pressure from 18.2 per cent at 140 lb. to 19.1 per cent at 160 lb., a gain of 4.7 per cent.

POWER PLANT ENGINEERING

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Relay Service for Hydraulic Stations

In the hydroelectric field of power generation, the greatest overall efficiency of the development is obtainable only by the full utilization of all of the water available. Both stream flow and power demand are bound to vary, the latter, however, not always in direct proportion to the former, and as a consequence design and operation complications ensue. During periods of peak load, the supply of water available may be but a small fraction of the maximum; unforeseen conditions arising since the erection of the plant may be responsible for a peak much in excess of the available output, while again extensive dry periods can be responsible for a curtailment of the service. All of these and perhaps many other elements enter into consideration and it is imperative, therefore, that if a hydroelectric development is to prove successful both financially and from an engineering standpoint, means be provided whereby continuity of satisfactory service be assured.

Any one or a combination of two or all of three schemes have proved satisfactory; the arrangement to employ is largely dependent upon local conditions. Frequently, and particularly so for the initial development, the required relay may be advantageously provided in the stream itself by the addition of reservoirs or merely pondage for the purpose of giving some artificial control of the stream flow, while in other instances interconnection of systems fed by plants located on dissimilar streams has been of material assistance in overcoming the difficulties involved. Most economical and satisfactroy, however, for providing supplementary power is the steam station and it is therefore obvious that engineers having aught to do with hydroelectric developments of any appreciable magnitude should give this phase of the subject their most careful and thorough consideration.

Steam stations of this kind may function either to make up a flow or head deficiency or as an emergency reserve. Their capacity is, of course, largely dependent upon stream flow and load, both present and prospective, and while their design is in general determined by such usual factors as location, power market, water and fuel supplies, fuels cost which control in the case of the average steam plant is in general, on account of the commonly low load factor, less dependent upon consideration of operating economy. Characteristics of load and continuity of service are, however, factors of vital importance as are also the characteristics of the hydraulic development and its relation to the load.

To arrive at any definite conclusion relative to the type and design of station to employ, numerous other elements and factors require consideration and it is only through actual experience or the perusal of a paper such as that of E. B. Powell, entitled Steam Stations for Hydraulic Relay Service, as published elsewhere in this issue, that it is possible to realize the importance of the subject and to gain a degree of the information so necessary as a preliminary if the design and construction of a plant of this kind is to be attempted. Mr. Powel has gone into considerable detail, still in such a manner as to make the article of unusual value both to the student and the hydroelectric man of long experience. He has not only analyzed the various phases of the subject as a whole, but has, in an exceedingly comprehensive manner, outlined the procedure or procedures to be followed under various conditions.

From Pioneering to Efficiency

In the development of any industry, science or profession, the first steps taken are more or less uncertain. Somebody makes a discovery or perhaps thinks he has discovered a new material or law governing material changes and he starts pioneering or investigating the truth and extent of his discovery. During these preliminary investigations, there is no certainty that what is expected will occur and the wise investigator proceeds with caution, working gradually to the limits of his ability and the ranges of instruments and equipment at his disposal.

Following the pioneer in development work is the scientist who, with precision instruments and laboratory methods, extends the limits reached by the pioneer and formulates laws and theories governing physical and chemical changes. It is upon the work of such investigators that most of the mathematical formulas, tables and charts in engineers' handbooks are based. The results which they obtain are commonly called theoretical, since they are obtained under conditions which are as nearly perfect as master minds in a complete laboratory are able to devise, regardless of cost or applicability to industry.

All of this work has as its ultimate goal the placing of Nature's laws, forces and materials at the disposal of mankind. Now comes the engineer who makes the application to industry. In many lines of engineering, the pioneer work has not been completed and in many more scientists are still investigating materials and the laws governing changes which no doubt will influence the engineering practice in years to come. So it is that the engineer is compelled to deal with machinery and equipment in all stages of development from that which is still an experiment even though the best available for the purpose to that which performs its work at close to the theoretically perfect point.

Economy in production is his goal and 100 per cent efficiency in all conversions of energy is recognized as the limit beyond which it is impossible to go. So, in the power plant, the successful engineer applies scientific methods to obtain higher efficiency throughout his plant. By carefully kept records, he discovers where his greatest losses occur and concentrates his greatest efforts here. Many times he will discover that the solution of a particular problem lies in a more careful choice of his equipment, that is, a change to machinery more highly developed, but more frequently it occurs that changes in the methods of doing work around the plant and in conserving wastes will give greatest returns for money expended.

In each power plant the problem of maintaining highest efficiency presents a slightly different phase, not so much because of the difference in equipment as because of the difference in the surrounding conditions, such as load factor, fuel, weather, employes, etc. So it is that each plant which attains high efficiency must go through the pioneering stage where the exact results of changes of conditions cannot well be predicted. During this stage in the power plant's history, when routine is being established, the greatest care must be taken to avoid mistakes and a masterful engineer is needed to carry the plant over to and maintain it at the efficiency or economical stage.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Hoover in the Cabinet

The appointment of Herbert Hoover to President Harding's cabinet as secretary of commerce is an event which is not only gratifying to all members of the engineering profession, but which is of great importance to the profession as a whole. Mr. Hoover's success as an organizer, administrator and director of important organizations dispel any doubts regarding his fitness for the job, and we shall, undoubtedly, witness some important changes in the department of which he will be head.

The fact, however, of Herbert Hoover's being an engineer is perhaps even of greater importance than his being so eminently qualified for the position. In the past engineers have refrained almost entirely from participating in politics and as a result we have had no representatives of the engineering profession in the executive or legislative branches of our government. This is regretable since an engineer, by virtue of his training, will usually seek to predetermine, accurately, the result of any contemplated plan rather than plan blindly with consequent disastrous results. His natural aptitude in collecting data and in the interpretation of intricate statistics adapt him admirably to his duties as an administrator. Much as a man's knowledge of politics may be of value to him in securing a political office, it will be found (only too obviously at times) that the successful performance of his duties in that office depend more upon his knowledge of the particular branch of the government he directs and his ability as an executive, rather than upon his political accomplishments.

That there are so few engineers in political offices is due to the fact that the engineer, as a rule, is averse to "mixing with politics." He, himself, therefore is partly to blame for the lack of representation the engineering profession has in Congress and in the administration as a whole, since he has shown but little inclination to alter this unfortunate condition.

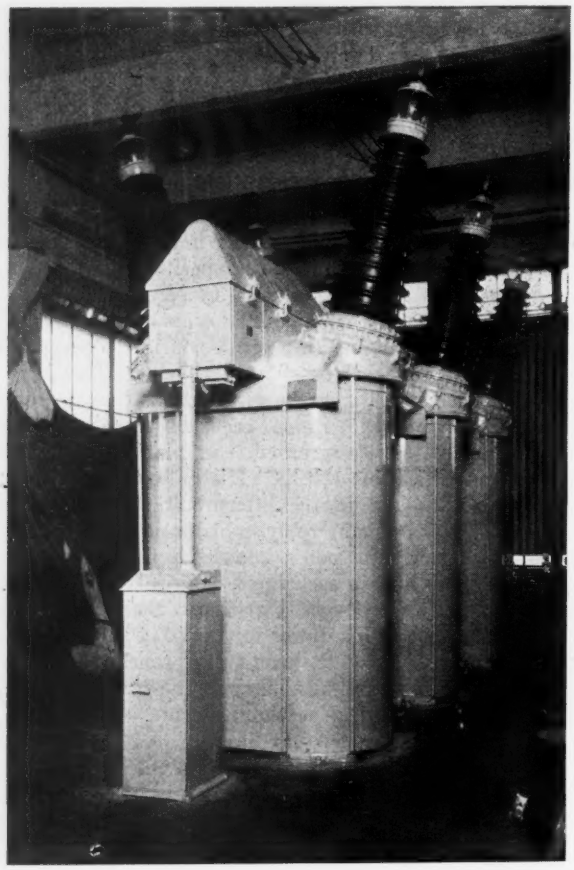
With Mr. Hoover's appointment to the cabinet comes the long-needed opportunity of demonstrating to the public whether or not engineers should participate in the management of the administrative affairs of the nation. In the performance of his duties Mr. Hoover will probably meet with vigorous opposition from political quarters, but we have no doubt as to his ultimate success and trust that this success will reflect upon the capabilities of members of the engineering profession. Once being convinced of the desirability of appointing engineers to certain of the administrative offices, the public will demand that the engineering profession continues to be represented.

Mammoth Oil Circuit Breaker

WHAT is believed to be the largest oil circuit breaker in the world, shown in the accompanying photograph, has just been built for the Great Western Power Co. of California. It is one of seven of the same size which are being built for that company.

The breaker is built for operation at 165,000 v., 400 amp. at any altitude from sea level to 4000 ft. It is solenoid operated, the solenoid being actuated through a relay energized by a bushing transformer. It is closed by means of a pull button switch located wherever convenient. The contacts, explosion chambers, etc., conform to the standard design of this type of breaker.

A few of the dimensions give an idea of the construction required for operation at such high voltage. The

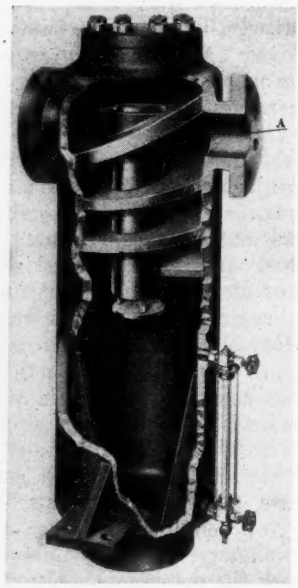


LARGE OIL CIRCUIT BREAKER BUILT FOR GREAT WESTERN POWER CO.

total length of the three units is 32 ft. and the height measured from the bottom of the tank to the top of the insulators is 16 ft. The complete apparatus weighs approximately 25 t., and requires over 4000 gal. of oil.

New Steam Separator

THE new separator shown in the accompanying photograph has recently been developed by the Griscom-Russell Co. and is a redesign of a former type of centrifugal separator manufactured by that company. It may be used for the effective removal of water from high-pressure steam before it enters the engine or turbine—at all velocities and regardless of the quantity of water present, or for the removal of water from compressed air before it enters air tools, sand blast machines, etc.



NEW CENTRIFUGAL SEPARATOR

Steam enters at A and is directed downward around the spiral path. The resulting centrifugal force throws the entrained water to the sides of the vessel.

In the new separator, the helical path has been lengthened, in order to increase the centrifugal separating action and this feature, together with the spatter cap on the outlet pipe, greatly increases the separating efficiency.

The separator is furnished in either cast iron or cast steel, for pressures up to 250 lb. per sq. in.

Turbine for Mechanical Drive

A NEW steam turbine for mechanical drive, that is for connection to centrifugal pumps, blowers, etc., has just been placed upon the market. This turbine is in principle of the standard Curtis type, but many of the details are worked out along modified lines based on experience.

Practical operation is given first consideration, and this turbine should require but a minimum of attention. All parts subject to stress are designed with a liberal margin of safety.

The turbine may be arranged to operate at steam pressures from 50 to 300 lb. with or without superheat, and either noncondensing or condensing. It is, in general, adapted to supplying an output anywhere from 10 to 400 hp. at 1000 and 5000 r.p.m. It may have one, two or three stages.

Figure 1 illustrates a complete two-stage turbine with speed governor mounted on one end of the shaft and the other end arranged for coupling fit. The connections

between the governor and governor valve are shown at the left, and adjacent is the emergency valve chest and resetting lever.

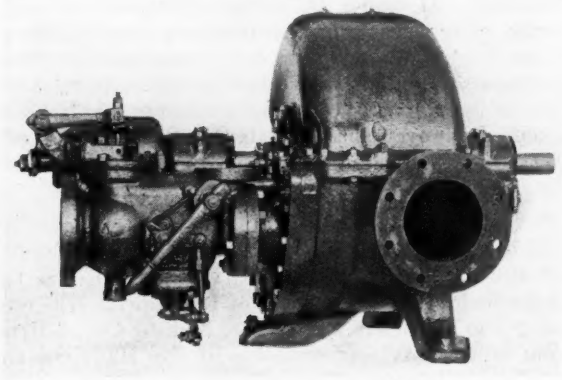
Figure 2 shows the same turbine with the upper half of the wheel casing and bearings removed. This permits removal of the wheels and shaft without disturbing the steam and exhaust piping.

The wheel casing is made of cast iron of ample body for safety and rigidity. It is divided horizontally into upper and lower halves, and the upper half may be readily lifted for inspection or removal of wheels. This may be done without breaking joints in the steam or exhaust pipes, as these are connected to the lower half of the wheel casing. The upper and lower halves of the casing are accurately machined and fitted together with metal to metal joint.

The casing is supported on three feet, which does away with the possibility of twisting strains.

The bearing brackets are bolted to the casing, and are bore-fitted to the casing, insuring absolute alinement of the bearings. These are made of top and bottom halves, consist of cast-iron shells babbit lined, and are lubricated by means of oil rings dipping into oil reservoirs of ample capacity.

The wheel consists of a steel disk turned to shape and keyed to the shaft. Two dovetail grooves are turned in the rim. The buckets are dovetailed into these grooves and are made of non-corrosive metal. Between the two



NEW TWO-STAGE TURBINE FOR MECHANICAL DRIVE

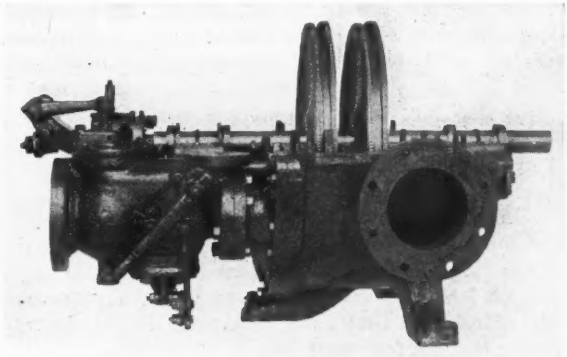
rows of revolving buckets in each stage are the stationary intermediate buckets for reversing the steam flow.

The shaft is made of steel with one end arranged for coupling fit, and the other carries the governor which is of the centrifugal tension spring type. The governor weights are pivoted on hardened knife edges of ample width to reduce wear to a minimum. Motion of the governor weights is transmitted through ball bearing connections to the governor valve. This valve is of the balanced piston type and is practically frictionless. Speed of the turbine may be varied while in operation by a simple adjustment of the governor valve.

The safety features of the governor are that the weights are completely enclosed in a casing, and, further, a protecting hood is placed over the governor as a whole.

In the steam chest in front of the governor valve is a wire mesh strainer to prevent solid particles from entering the turbine.

When conditions of operation render it desirable, an emergency governor is supplied. This operates entirely independently of the main governor and serves as an added protection. It does not come into play unless the speed rises to about 15 per cent above normal when it shuts off the steam supply. This governor is of the simplest possible construction consisting of two flat springs secured at one end to a disk. When the position of the springs, or of either one of them, is altered by



TURBINE SHOWING TOP HALF REMOVED

centrifugal force, it strikes a trigger which releases a simple flap valve in the steam chest and stops the flow of steam.

From the steam chest the steam is passed through the first stage nozzles which direct the flow of steam at the correct angle and velocity into the buckets on the wheel. For some purposes some of the nozzles are opened or closed, as required, by hand valves, placed in the steam chest. Steam to all nozzles is under control of the main and emergency governors.

Soft fibrous metallic packing is, in general, used where the shaft passes through the casing, but for condensing and high back pressure operation carbon packing is employed. A steam seal is provided for condensing operation.

Nashua Machine Co. Reorganizes

THE PLANT of the Nashua Machine Co., at Nashua, N. H., was destroyed by fire on the night of Friday, Dec. 31, 1920. While the ruins were still smouldering, plans were made for the prompt resumption of business, and a re-organization has been effected under the name of Nashua Machine Co., Inc., with John Sabin as president and general manager, Fred C. Sabin, vice-president and superintendent, and Eaton D. Sargent, treasurer, thus continuing in the active management of sales and production departments those who have been principally responsible for the greatest improvements in the product and most rapid development of the business.

Mr. Sargent, the new treasurer, is treasurer and general manager of the White Mountain Freezer Co., of Nashua. He brings to the Nashua Machine Co., Inc., a wealth of experience gained in other highly successful businesses, and is regarded by his associates as a most valuable acquisition.

The manufacture of Bundy steam traps was begun in 1890 or 1891 by the Pepperell Machine Co., under the management of John Sabin. It was taken over in 1893 by the Nashua Machine Co., Mr. Sabin continuing as general manager.

In May, 1894, A. A. Griffing Iron Co. became exclusive sales agents for Bundy steam traps, taking over the entire output of the factory at Nashua, and shortly thereafter were joined by Mr. Sabin.

On April 5, 1911, the Nashua Machine Co. resumed the marketing of Bundy steam traps and re-organized its sales force, with John Sabin as sales manager, with headquarters at Boston. This arrangement continued until April 1, 1915, when the business had grown to such an extent that Mr. Sabin was obliged to remove his headquarters to Nashua, and to broaden materially the scope of his activities, which he has since done as the general manager.

Mr. Sabin's son, Fred C., the new vice-president and superintendent, has been associated with his father in the trap business almost from boyhood. He shares with his father the credit for many of the improvements and refinements that have been made in Bundy traps during the past few years.

The directors and stockholders of the Nashua Machine Co., Inc., are composed wholly of Nashua business men whose successful experiences and ripened judgments are confidently expected to increase still further the prestige of this pioneer concern.

While operations are going forward in temporary quarters, machinery and equipment are being installed in a new factory, just purchased by the company, which is much larger than the old one and is located in the heart of Nashua. It is expected that production will be resumed in a larger way and under more favorable conditions than ever before by April 1.

The same force of engineer representatives is to be continued at the various locations in this and other countries.

News Notes

FITZGIBBONS BOILER CO. announces the removal of its office from its temporary location at 1181 Broadway to its former location at 17 Battery Place, New York.

THE POWER MANUFACTURING CO. of Marion, Ohio, announces the opening of an office in New York City, which is in charge of H. L. Dean, and is located at 114 Liberty St., Room 1002.

THE VULCAN SOOT CLEANER CO. of Du Bois, Pa., announces the appointment of C. L. Simonds as vice-president in charge of western sales, with headquarters at 828 Transportation Building, Chicago, Ill., succeeding the Ernest E. Lee Co.

OWING to the trend toward higher voltages which is being initiated in the west, and which will ultimately extend to all parts of the United States, the Westinghouse Co. is building a complete, modern, high-voltage, experimental laboratory. In this laboratory will be installed two transformers, one rated at 1,000,000 v., 1000 kv.a., the other rated at 500,000 v., 500 kv.a. They can be connected together, and 1,500,000 v. can be obtained between terminals. This will allow voltages for flashover testing as high as 1,500,000 v. The laboratory will be 120 ft. long, 110 ft. wide and 50 ft. high, without columns of any sort. High-voltage insulators, transformer terminals and circuit-breaker terminals will be tested in this plant.

ELLIOTT CO., Jeannette, Pa., announces the following changes in the company's sales organization: W. A. Darrow, who has been district sales manager of the Philadelphia office, becomes special representative with headquarters in Philadelphia. T. F. Crawford, formerly St. Louis district sales manager, has been transferred to the Philadelphia office in the same capacity. C. L. Draper, who has been with Kansas City office, becomes district sales manager of the St. Louis office. M. C. Sickels of the Cleveland office becomes Cleveland district sales manager, succeeding D. S. Tucker.

N. C. HOYLES has been appointed manager of the Cincinnati branch of the Pittsburgh Testing Laboratory at 813 Race St., Cincinnati, O. From 1909 to 1914, Mr. Hoyles was manager of the Birmingham, Ala., branch of this company. In 1914, he joined the Canadian military forces, went overseas with the Canadian Engineers and at the close of the war was mustered out with the rank of lieutenant-colonel. For the past year he has been assistant manager of the Pittsburgh Testing Laboratory's New York office.

DWIGHT P. ROBINSON & CO., INC., has recently opened branch offices in Montreal in the Dominion Express Building. Alexander C. Barker, vice-president, is in charge of the office. The company is a consolidation of Westinghouse, Church, Kerr & Co., Inc., and Dwight P. Robinson & Co., Inc., and has done extensive construction and engineering work in Canada for the Canadian Pacific Railway, Canadian Salt Co., Canadian Crocker-Wheeler Co., Dominion Government, Aetna Explosives Co., Grand Trunk Railway and others.

WM. W. NUGENT & CO. will move into its new factory building about April 15. This building which is located at 410-412 N. Hermitage Ave., Chicago, Ill., has two floors with a total floor space of 1200 sq. ft. The company also announces that Catton, Neills & Co., of Honolulu will be its representative in the Hawaiian and Philippine Islands.

THE CONVEYORS CORPORATION OF AMERICA announces that S. D. Inman has been placed in charge of the engineering and design of their trolley carrier, monorail conveying equipment for handling coal, ashes, sand, gravel, and like bulky materials from railway car to pile, bin or bunker.

THE LOCOMOTIVE SUPERHEATER CO. announces the election to vice-presidencies of the company of Gilbert E. Ryder, Henry B. Oatley and Charles H. True.

Mr. Ryder, who will have charge of sales with office in New York, studied engineering at the Universities of Wisconsin and Illinois, served 5 yr. as an apprentice and a journeyman in the mechanical department of a railroad, practiced engineering in the fuel testing bureau of the United States Geological Survey, served the City of Chicago as deputy smoke inspector in charge of locomotives, was an editor of the Railway Review, after which he entered the service of the Locomotive Superheater Co. 10 yr. ago.

Henry B. Oatley has been selected to take charge of engineering with offices in New York. He received his engineering education at the Universities of Rochester and Vermont, then entered the service of the Schenectady Locomotive Works. Since 1910 he has held positions in the mechanical engineer department of the Locomotive Superheater Co. except for a time spent as an officer in the U. S. Navy during the war.

Charles H. True, who will have charge of production with offices at East Chicago, Ind., received his technical education at the University of Nebraska, and immediately upon graduation entered railroad service in shops and round houses, advancing to assistant superintendent of shops. In 1905 he entered the employ of the Railway Materials Co. as mechanical engineer and in 1912 became works manager of the Locomotive Superheater Co. at East Chicago, which position he held at the time of his recent advancement.

Book Reviews

MODERN MARINE ENGINEERING, Vol. 1, "The Fire Room," by Harry G. Cisin; 206 pages, 68 illustrations, cloth; New York, 1921.

The purpose of this book, as stated in the preface, is to reflect present-day practice in marine engineering. While primarily intended as a text for schools and colleges, it has also been adapted to the needs of the practical man who desires to broaden his knowledge and to advance in his profession.

To the man preparing to qualify for an engineer's license, the book provides an intensive course planned to fit him for his responsibilities as an engineer officer. It aims to teach the fundamentals rather than to present an assorted collection of questions and answers culled from previous license examinations.

The present volume, while essentially a detailed discussion of marine boiler construction, also contains sections on boiler room auxiliaries, boiler corrosion, fuels and combustion. General theory, including definitions, calculations, steam tables, etc., is given in the final chapter.

The framework of the book was derived from the marine engineering course given during the war, by the U. S. Navy Steam Engineering School at the Stevens Institute, Hoboken, N. J.

HYDROELECTRIC DEVELOPMENT IN ONTARIO, by E. B. BIGGAR; 202 pages; 15 illustrations, cloth; Toronto, 1920.

This, which essentially is a history of water power development and administration under the Hydroelectric Power Commission of Ontario, should prove valuable and interesting alike to the engineer and to the student of public affairs. The former will find much therein to indicate the possibilities of water power development not only from the standpoint of generation but also the transmission, distribution and utilization of electric energy derived from this source. Of particular interest is the fact that this body beginning as an insignificant distributor of electric energy, has within the brief space of a single decade become the largest generator as well as distributor of hydroelectric power in the world and this on a co-operative basis with the city and rural municipalities served. It is a new adventure in the matter of local government and a demonstration of successful municipal control and operation of public utilities. Thus its value to the student of public affairs.

In general, Chapter I sets forth the right of the public, based upon the Divine command, to control such service as transportation on highways, railways, waterways, the generation and distribution of hydroelectric energy, while Chapters II and III set forth in detail the natural energy resources of both the United States and Canada, their effect upon colonization and industrial development, and a discussion of the origin of the Niagara Falls National Park and their relation to the power question.

In the following chapters are included such topics as a sketch of the constitution, the relation of the municipalities to the Commission, the plan of administration, a technical description of the power systems, and the development of the water powers of the Province by which Ontario now generates through hydroelectric energy over 95 per cent of its power from all sources—a ratio exceeding that of any political division of the world.

What the Commission has done and what private companies have left undone in developing electric power for the farmers is discussed in Chapter XVI. The following chapter considers the problem of the vast potential water powers of the St. Lawrence along the International boundary line.

The subject is in general handled in an exceedingly able manner by the author, who is well known in Canada as founder and former editor of the Canadian Engineer.

HEAT ENGINES, by D. A. Low; 592 pages, 656 illustrations and 315 exercises; first edition, 1920, London, Eng.

Strictly speaking, the title of this book is somewhat of a misnomer; for although a large portion of it is devoted to heat engines, more than one-third has to do with such subjects as heat and work, expansion and compression of gases, the properties of steam, ideal heat engine cycles, combustion and fuel, and steam boilers and their performances. In general, it is rather a text on heat engineering.

Essentially this is a book for use in technical and engineering schools and as the author explains in the preface, has been prepared on the assumption that the student will spend a considerable length of time in working out the numerous exercises which are found given at the end of each chapter. This is a particularly valuable feature of the volume.

The illustrations, which have been made comparatively small evidently to economize space, are clean cut and well serve their purpose.

Chapter XII, which follows the discourse on boilers, is devoted to a discussion of the various types of reciprocating engines in use today while Chapter XIII is devoted to the subject of the structural details of these machines. Indicators and indicator diagrams are taken up in the two following chapters with a consideration of the subjects of crank effort diagrams and flywheels, governors, valves and valve gears and performance of reciprocating engines in Chapters XVI to XIX, inclusive.

Steam turbines, condensers and air pumps and internal combustion engines receive much attention in the concluding sections of the book. The treatment accorded

the latter is especially worthy of mention both in regard to the manner in which the subject is handled and the extent to which the author has gone to cover the ground in as thorough a way as possible.

CAMS, ELEMENTARY and Advanced, by Franklin De Ronde Furman; 234 pages, 6 by 9 in., 182 illustrations, first edition; New York, 1921.

The first five sections of this book were published about 3 yr. ago under the title of "Elementary Cams." The chief features of this earlier book were that it pointed out a classification, an arrangement, and a general method of solution of the well-known cams in such a manner as has been generally developed in other specialized branches in technical engineering work.

The chief original features of the present advanced book include the development or use, or both, of the logarithmic, cube, circular, tangential and involute base curves, the establishing of cam factors for such of these curves as have general factors, and the demonstration that the logarithmic base curve gives the smallest possible cam for given data.

The material given includes also the comparisons of the characteristic results obtained from all base curves in which the relative size of each cam, and the relative velocity and acceleration produced by each, is shown graphically in one combined group of illustrations. This enables the designer to glance over the entire field of theoretical cam design and quickly select the type that is best adapted for the work in hand.

All of the material is fully and clearly presented, the processes of design being mostly graphical and readily followed by practical shopmen and draftsmen, as well as by technical students.

Trade News

CATALOG No. 200, issued by J. E. Lonergan Co., not only illustrates and describes products manufactured by this company, but gives a reprint of the A. S. M. E. Code covering safety valves and tables of the discharge capacities of different sizes of safety valves.

A FOLDER descriptive of the Yarway Junior seatless valve, developed by Yarnall-Waring Co., Philadelphia, to stay tight under high-pressure steam on turbine drips, superheater drains, water columns, blowoffs, etc., was recently issued. Copies of this leaflet will be sent, on request, to those interested.

BULLETIN No. 607, containing a comprehensive description and several applications of Chicago Pneumatic oil engine driven compressors, built in both stationary and portable types, also a comparison of their operating cost with that of steam driven compressors, has just been received from Chicago Pneumatic Tool Co., New York.

THE MANY important economies in generation, control and distribution of electrical energy developed by automatic stations are presented in Bulletin No. 47,730, issued by the General Electric Co., and entitled "Automatic Station Control Equipment."

The bulletin, in addition to showing illustrations of various installations, gives a partial list of equipments and refers to a list of technical articles which have appeared in this as well as other leading magazines on the subject of automatic station control equipment.

THE LAKEWOOD ENGINEERING Co., Cleveland, O., is distributing a new 16-page booklet in two colors illustrating clamshell buckets in use on various types of cranes. The whole story has been told in pictures.

LEAFLET 1160-A, which has just been issued by the Westinghouse Electric & Manufacturing Co., illustrates and describes the features of the Type CS squirrel-cage induction motors of this company. These motors are constant speed, continuous rated from 2 to 200 hp., two and three-phase with 25, 40, 50 and 60 cycle, and 110, 220, 440, 550 and 2200 v. In addition to the discussion on the motor and its parts, the Type A auto starter and the Type 815 motor starting switch for 10-hp. motors and below are illustrated.

THE GRISCOM-RUSSELL Co. has recently published a 29-page illustrated booklet entitled "The Cooling of Quenching Oil in the Heat Treatment of Steel," by Kenneth B. Millett. This describes in a readable manner the necessity for heat treatment, the various quenching mediums and systems commonly used and the advantages of continuous circulation of the medium. Typical installations are featured, showing the layout of the piping with recommendations for the proper size and number of coolers to meet the requirements.

CATALOG No. 257 on Jeffrey Standardized Scraper Conveyors features both single and double strand conveyors designed to handle all kinds of loose products in manufacturing and mining industries, power plants, retail coal yards, canning plants, sugar mills, and practically all other industries. The many pages of instructions, specifications and dimensions given have been compiled in such a way that the engineer and often the purchaser who is more or less unfamiliar with engineering problems, may easily select the right conveyor to fit his needs.

This catalog is now ready for distribution, and will be sent free to interested persons upon request to The Jeffrey Manufacturing Co., Columbus, O.

FOR THE purpose of supporting switchboard panels and accessories, the General Electric Co. has standardized commercial piping; and to enable the user to make installations of these equipments readily and easily, a complete line of special threadless pipe fittings for the many forms of mountings involved has been designed. Bulletin No. 47,703-A, superseding Bulletin No. 47,003, appears from the press of the company and describes, lists and illustrates these specialties in a most complete manner.

These fittings are equipped with bolts or bolted clamps quickly attached. Drawing exhibits the application both of panel and benchboard fittings and mounting of devices. All fittings are also separately illustrated and accompanied by individual dimension drawings for convenience in making layouts.

The assortment comprises: clamps for panel and base mounting; clamps for joining pipes; clamps and floor angles for angle irons and resistance supports; oval and half-oval floor flanges; clamps and floor clevis, all for flat surfaces; cap, wall support and clamps for supporting miscellaneous apparatus; clamps for benchboards; panel pipe supports, etc. The several fittings embrace suitable sizes in comformity with conventional requirements.